DOCUMENT RESUME

ED 208 863 IR 009 775

AUTHOR Rubin, Martin L.; And Others
TITLE Evaluation of Biomedical Computer-Assisted Instruction from a User/Institutional Viewpoint. Final Report.
INSTITUTION Human Resources Research Organization, Alexandria, Va.
SPONS AGENCY National Library of Medicine (DHEW), Bethesda, Md.
REPORT NO HumRRO-FR-ED-76-37
PUB DATE Sep 76
CONTRACT N01-LM-5-4751
NOTE 113p.

EDRS PRICE MF01/PC05 Plus Postage.
DESCRIPTORS Academic Achievement; *Biomedicine; *Computer Assisted Instruction; Questionnaires; School Surveys; Student Attitudes; Teacher Attitudes; Teacher Participation; *Use Studies

ABSTRACT

This study focuses on the experiences of eight biomedical institutions which have undertaken the development of computer assisted instruction (CAI) projects and answers specific questions about the utilization of CAI in these institutions. The study examines the CAI development projects from a number of perspectives including: (1) attributes of students who use or do not use CAI materials, (2) characteristics of faculty who participate in CAI development, (3) incentives utilized to stimulate faculty participation in CAI, (4) experience with transferring CAI systems to other educational environments, (5) effectiveness of various computer assisted instructional modes, and (6) impact of CAI on student achievement. Fourteen references are provided, as well as a list of contract personnel from the various biomedical institutions involved in the study, a sample survey form used to collect data, and a list of initializations and abbreviations used in the report. (Author/LLS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

HumRRO

Final Report
76-37

HumRRO
FR-ED-76-37

ED208863

Evaluation of Biomedical Computer-Assisted Instruction From a User/Institutional Viewpoint

by

Martin L. Rubin,
Marilyn Knetsch, and
Richard Rosenblatt

HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street • Alexandria, Virginia 22314

September 1976

Prepared for

National Library of Medicine
8600 Rockville Pike
Bethesda, MD 20014

IR009775

FOREWARD

This report documents the findings of the study of medical school CAI experiences under project MEDSURVEY. MEDSURVEY is a research project undertaken by the Human Resources Research Organization (HumRRO) under Contract No. NO1-LM-5-4751 to seek answers to specific questions about the nature of the CAI developments.

The research and development is being conducted at HumRRO's Eastern Division where Dr. J. Daniel Lyons is the Director. Martin L. Rubin is the Principal Investigator for this project.

The principal investigator is indebted to the participating medical schools for their cooperation in sharing their experiences and developments.

EXECUTIVE SUMMARY

A major investment in the development of a library of CAI (Computer-Assisted Instruction) materials has been made by the federal government and by individual institutions. This study focuses on the experiences of eight biomedical CAI developing institutions and attempts to answer specific questions about the utilization of CAI.

A brief synopsis of the eight institutions selected for this study is given below.

University of Kansas Medical Center

CAI development at this institution is located within the Department of Pharmacology. The Computer-Assisted Teaching System (CATS) integrates the use of CMI (Computer-Managed Instruction) and CAI. A consortium of some 25 medical schools uses the CATS system. The heart of the CMI portion of the System is a test item bank containing some 14,000 questions which have been contributed by various consortium members. The CAI portion of the system consists principally of tutorials and case histories.

University of Wisconsin School of Medicine

The CAI effort at this institution is organized under the Department of Medicine. The project is devoted to research in simulated encounters for student instructional use and as a evaluation vehicle for recertification.

University of Illinois-Urbana School of Basic Medical Sciences

The School of Basic Medical Sciences has a non-traditional educational program in which the computer is used to manage the self-guided study, and as a teaching tool. The teaching materials are developed by a CAI special staff.

Cornell University Medical College

CAI development at the Cornell University Medical College resides in the Laboratory of Computer Science under the Department of Anatomy. Cornell uses A Tutorial System (ATS) which permits the computer to simulate human discourse and facilitates the authoring process. The instructional units are principally in gross anatomy, microscopic anatomy, and neuroscience, and programs in pharmacology are now under development.

University of California at San Francisco

CAI activity at the San Francisco Medical Center is in the Computer Center of the Office of Information Systems and has primarily focused on system development rather than instructional use. The Center has developed the Programmed Inquiry, Learning or Teaching (PILOT) language. This language allows CAI authoring by non-computer experts. The PILOT system can be used for traditional tutorial frame-oriented programs as well as programs providing practice with simulated clinical situations using natural language input. Instructional materials in pharmacology have been developed for use on a small, stand-alone computer, written in the PILOT language.

UCLA School of Medicine

The planning of the use of educational technology is under the auspices of the Office of Educational Research, however, there is no project group or department with ongoing activity in the development of CAI materials. Sporadic development of CAI materials has been done by individual faculty members.

University of Alabama School of Medicine

CAI at this institution was limited to a small research project which has been suspended. The principal research effort was the development of a simulation of the team approach to medical practice.

University of the Pacific, Pacific Medical Center

The Model for Evaluation and Recertification through Individualized Testing (MERIT) project at the Pacific Medical Center, supported since 1973 by the American Board of Internal Medicine, is a developmental effort aimed at a model for recertification of practicing internists. The project utilizes the CASE natural language model as the examination instrument which provides simulated clinical encounters constructed from actual cases.

QUESTIONS ADDRESSED IN THE STUDY

This study examines the CAI development projects from a number of perspectives:

- Attributes of students who use or do not use CAI materials.
- Characteristics of faculty who participate in CAI development.
- Incentives utilized to stimulate faculty participation in CAI.
- Experience with transferring CAI systems to other educational environments.
- Effectiveness of various computer-assisted instructional modes.
- Impact of CAI on student achievement.

Study Question:	If students using CAI have specific attributes, what are they?

Study Habits

Study habits and attitudes are one of the most important non-cognitive dimensions influencing CAI usage. In some situations they may act as the over-riding influence; that is, a student who would tend to be a heavy CAI user because of his general disposition to self-directed study may not use the computer if it conflicts with his study habits. Study habits and attitudes include many dimensions such as:

1. Ability to work well under deadline pressure versus working best with little or not pressure. The importance of this factor was revealed at Cornell University and the University of Kansas. At Cornell, there is pressure to attend scheduled lectures, laboratories, and to fulfill curriculum requirements. On a student survey the overwhelming reason given for non-CAI use was the unavailability of time to use this learning resource. At the University of Kansas there is less deadline pressure. The students in the independent study program have 4 1/2 months in which to complete their pharmacology unit. The average mean usage of students at Kansas was 23 hours as compared with only 6 hours at Cornell.

2. Preference for studying concrete materials such as facts and practical applications versus studying abstract materials such as principles, concepts, and theory. The CAI materials at the University of Kansas are factual in nature. Several of the students interviewed indicated that they avoided using the computer because they wanted to develop an understanding of general principles, e.g., the basis of drug therapy.

3. Preference for teacher directed/structured study versus self-defined/student structured objectives. There appears to be a relationship between student study objectives and preferences and CAI usage for various types of instructional materials.

If a student is interested in satisfying teacher-structured objectives to learn a body of materials (learning what the instructor emphasizes as important), and if he perceives the CAI materials as an aid toward achieving that goal, then he will be a high CAI user. A large number of students at the University of Kansas were motivated to use the computer for this reason.

The reason I used the CAI as much as I did was that the questions on the CAI tended to appear on the exams. I believe that the course would be much improved if a complete series of good lectures was provided. These should follow the syllabus and the syllabus itself should be re-written. It contains many errors and many confusing sections. The idea of self-directed study is good and should be retained.

Students at the University of Illinois were not heavy users of CAI since they perceived the materials to be tangential or supplementary to the topics being taught. If the materials are intellectually challenging, however, students may make heavy use of auxiliary materials. Certainly this was a factor in the student use of the Massachusetts General Hospital clinical encounters during the Lister Hill Biomedical CAI network experiment.

4. Study habits in the areas of reading, note taking, habits of concentration, distribution of time and social relationships in study, and general habits and work attitudes. A number of students interviewed were explicit about their reliance on reading and note taking over other methods of study.

I preferred studying at home on my own hours; and I considered CAI, from previous exposure, to be inefficient compared to my own reading. If the syllabus had not been available (and I wish it had been more comprehensive) however, I might have used CAI more for direction.

Students at the University of Illinois rely almost entirely on this method of learning. Attendance at lectures is optional; attendance seldom rises above 50% and is often much lower. Another factor is scheduling of available time.

The real problem is that if I came over here, that's a commitment of time. If the terminal was not available then I have wasted the time I need to use to study pathology or pharmacology. What I am saying is that I would have used the computer more if it had been accessible at any time I wanted it. If I could program it into my schedule. What's important to me is that I have as much control as possible over my schedule. In medical school that's not possible. I attended almost all of my classes. I didn't attend classes in pharmacology, but I did in everything else.

There is a dichotomy between those who find textbook reading and lectures an efficient method of learning and those who would prefer CAI because of its interactive nature.

> *I appreciate most the opportunity to review a program more than once, i.e., to view a program, study on my own, and view it again. The opportunity to see my own progress was encouraging. Frequent feedback was very helpful. The CAI course unit exams were also valuable in self-assessment. None of these features can be had in the traditional lecture/lab/discussion type of course design.*

Cognitive Ability

In the area of cognitive ability, the question of whether or not there is a significant difference between users and non-users of CAI was addressed. In our student survey at the University of Kansas, MCAT scores were obtained for science, verbal, general information, quantitative ability as well as GPA for randomly selected groups of high and low CAI users.

These scores and averages were analyzed by means of Multiple Discriminant Analysis, a multivariate statistical method for determining the extent to which discreet groups differ in terms of a set of continuous variables. While the results of this analysis indicated that the five measures entered into the analysis do not discriminate the high and low user groups at conventional levels of statistical significance, the data strongly indicate that the low-use group of the Kansas tutorial is generally brighter and has better academic records than the high-use group.

It might be tentatively suggested that *the brighter students, accustomed to consistent academic success via their own methods of study, did not view the computer-based materials as particularly necessary or important to obtaining a good grade in pharmacology--especially in light of the fact that such study was on their own time.*

Conversely, it has been observed by Dr. Richard Friedman at the University of Wisconsin School of Medicine that the brightest students were the ones who came back repeatedly to work up the clinical simulation cases.

Therefore, the tentative conclusion is that the relationship between academic ability and usage is affected by the type of instructional material offered.

Study Question:	Can any generalizations be established about the types of faculty involved in developing CAI materials?

It is useful to take a close look at the characteristics of those faculty members who have developed CAI materials. Attributes which have a bearing on who participates in technology-based instructional development projects are:

1. Educational background
2. Faculty position
3. Developer age
4. Tenure status
5. Prior CAI experience
6. Prior teaching experience
7. Primary professional focus

For each of these characteristics a hypothesis was selected for investigation.

Educational Background

- Faculty members who hold PhDs in scientific disciplines make up the majority of CAI development participants.

Of 67 participants, only 14 fell into this category. They did, however, outnumber those with PhDs in educational or psychological disciplines.

Faculty Position

- Low-level faculty members (instructors and assistant professors) have a larger role in CAI developments than do high-level faculty (full and associate professors).

The study revealed that faculty participation is dominated by senior faculty: 32 of 39 faculty participants were either full or associate professors.

Developer Age

- Faculty members who are under the age of 40 are the predominant participants in CAI development.

The over-the-hill gang won out! Of the 39 faculty participants, 2/3 are over the age of 40.

Tenure

- Untenured faculty who are not committed to traditional teaching methods are the predominant participants in CAI development.

Our investigation revealed that over 2/3 of faculty participants hold tenured positions. We speculate that tenured faculty have less reason to be concerned about the proclivities of their departmental chairmen and are thus more willing to experiment with alternative instructional modes.

CAI Experience

- Prior experience with computers in instruction is a prerequisite of participation.

This hypothesis was supported. Of the 39 faculty participants, 27 have over two years' experience with CAI, and many of these have experience of 10 to 15 years.

Teaching Experience

- Faculty members with under 15 years' teaching experience are the predominant CAI development participants.

To the contrary, the majority of faculty participants have substantial teaching experience.

Primary Professional Focus

- Teaching or educational research, rather than scientific research, is the primary professional interest of most CAI development participants.

The study revealed that 21 of 39 faculty participants have scientific research as their principal interest.

Study Question:	If incentives for faculty development of CAI have been offered, what are they and have they proven effective?

At the outset of the study we anticipated that the following incentives for participation in CAI development would be present:

1. Personal interest in teaching innovations.
2. Release time from teaching/research responsibilities.
3. Royalty income.
4. Promotion credits.
5. Recognition for educational research.
6. Salaries for development of CAI materials.
7. Departmental/administrative support.

The study revealed that financial remuneration was the Number 1 incentive for materials development but these payments tend to be given to staff and student content developers rather than to departmental faculty. This was the case at the University of Illinois and at Cornell University.

The main incentive for faculty participation in CAI development at the University of Kansas Medical Center is the support of the departmental chairman. Also, the faculty has received recognition, since their department has been repeatedly voted "best teaching department" by students.

At the University of Wisconsin the personal interest of the project director, Dr. Richard Friedman, and research dollars obtained for study of clinical problem-solving are the primary incentives. Dr. Friedman has personally developed all of the cases currently available. The Chairman of the Department of Medicine has been supportive of Dr. Friedman's work but, in contrast to Kansas, he has not taken an active interest in the research.

Study Question: How was off-campus sharing accomplished? What problems were encountered with sharing CAI materials?

Transfers of CAI materials were, in most cases, accomplished manually with special conversion projects.

Loma Linda University School of Medicine imported the Wisconsin clinical simulation system. The system was converted to run on a Data General Nova mini-computer, using time-sharing BASIC language. A medical school student spent 2 1/2 months working, in his spare time, to convert the system. The total cost was under $1500!

The University of Illinois chose to import only the CAI portion of the University of Kansas' CATS system. Since Illinois has the PLATO system which uses the TUTOR language, it was necessary to accomplish the translation manually. However, this posed no special problem and was accomplished by students in approximately three weeks. Illinois has made no modifications to existing CAI materials or developed any new ones.

Jefferson Medical College in Philadelphia imported both the CAI and CMI programs from Kansas. Twenty to thirty thousand dollars was spent for initial system conversion, primarily for systems analysis time. Jefferson's pharmacology faculty has written 8 to 10 of their own CAI tutorials in COBOL and Assembler.

Kansas has taken these programs and manually translated them into Coursewriter and has made that version of the programs available to the CATS Consortium.

Cornell University has a unique technical problem in sharing. All of their programs presently operate under ATS which uses as its native language a non-standard version of APL. Prior to the four years of non-standard APL, when Cornell did have standard APL, the ATS system itself was provided to a number of schools including the University of South Florida, SUNY-Binghamton, and the University of Hawaii.

There has been one attempt to manually translate the CAI tutorials from APL to TUTOR. One program was translated but Cornell felt that the translation was a poor rendition since it did not contain the instructional strategy built into ATS.

Study Question:	Which modes of CAI instruction have the institutions chosen to emphasize in their programs? Do data exist on their effectiveness versus the effectiveness of traditional teaching and testing methods?

Clinical Simulation

The normal pattern of the physician-patient encounter begins with an introductory screening describing the clinical situation, followed by a summary of patient physical characteristics and the circumstances of his visit; then, an unstructured interview on history questions and physical exam findings. Interim patient management, laboratory testing, diagnosis, and management planning is then performed.

Twenty eight internists using the University of the Pacific CASE system gave the following ratings:

- 93% rated the case simulations as an appropriate and desirable testing mechanism for recertification.
- 88% felt the cases in their exam were representative of the patients in their practice.

- 82% felt that the cases were similar to their behavior with actual patients.

In terms of simulation realism one measure is the ability of the system to respond to unstructured questions. The average response rate for the various cases was between 90 and 96%. This means that the computerized patient was able to make an appropriate response to the physician's inquiries in nearly every instance, which indicates that the cases are highly refined. This explains why one physician became so engrossed that he momentarily forgot that the patient was not real and became very upset when he missed the diagnosis and the patient's life was threatened.

In a survey, third year University of Wisconsin medical students rated the usefulness of simulated patient encounters between 3.7 and 4.0 on a 5-point scale. However, the students do not think that simulations accurately represent their experience on the floor.

> *I gained much more from the equivalent time spent in our clinical evaluation--being thrown a totally unknown patient to interview and examine and present to a strange staff physician cannot be beaten as a stimulus to organize one's medical information in a useful way, i.e., get it together.*

Gaming

In a gaming situation students compete with one another in the identification of chromosomes. The game does not require all contestants to be present at once. The game is ongoing, and each students may "play" as often as he wishes whenever he wishes. He can request his standing in the competition at any time. Students also have the option to merely take the exercise without competing.

In one exercise the student plays the part of a clinical geneticist. A case is randomly presented to him. This exercise allows practice in genetic karyotyping. A number of the chromosomes are similar in appearance, and repeated observation is helpful to build skills. If a wrong identification is made the computer indicates the correct choice.

No data were available to prove that this mode is more effective than a lecture, but it certainly is difficult to duplicate this exercise on a blackboard.

Dry Lab Simulations

In performing a dry lab simulation, a student may, for example, simulate the cardiovascular effects of chemical agents. He may observe the effect on blood pressure with the injection of a saline solution. An agent can be injected which will have an interaction with other agents already dumped into the system. The student is asked to figure out what other agents are present in the blood stream.

Unfortunately there are no data on this mode's effectiveness; however, it has certain advantages when compared to a wet lab. Each student individually conducts his experiment, while in a wet lab he would normally be working in a group. Also, a student is given "personal" attention and can immediately see his errors.

Tutorials

In a survey at Cornell University the students, on a question of the contribution of tutorials to learning, found them to be worthwhile but somewhat time-consuming and tedious.

Students at the University of Kansas who participated in our survey ranked CAI against other media as follows (with the highest ranking appearing first):

1. Syllabus
2. CAI
3. Textbooks
4. Tests (unit exams as a learning method)

Study Question: Does CAI improve student performance?

Data on this question were sparse. However, student grades in pharmacology were available and a two-sample Kalmogorov-Smirnov test was made on the high and low computer usage groups. The results showed that grade performance of the high user group was significantly better at the .05 level.

It would appear that the effect of computer practice manifests itself in raising marginal performance on pharmacology unit exams to a rating of satisfactory, and in few instances, to superior.

The most outstanding gain in performance was reported by the University of Hawaii, School of Medicine. Their ranking on the national board, pharmacology section, went from 38 in 1973 to 4th in 1974 and it was 9th in 1975, after the University of Kansas CATS CMI system was adopted in 1974. Since the quality of students was going up during this period, it is not possible to unequivocally state that CMI was responsible for this substantial improvement, but it is reasonable to assume that computer-based system made a contribution.

There were no data to show that clinical encounters improved overall medical students' grades. Scores on the clinical encounters were compared with written exam scores and ward rankings but no correlation was found. It may be that the clinical encounters measure different skills than are being measured by the other methods. More research in this area is needed.

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	i
Chapter I. STUDY PLAN	1
Introduction	1
Study Methodology	3
Participating Institution Profile	3
Chapter II. STUDENT ATTRIBUTES	7
Study Preferences and Habits	7
Academic Ability	21
Personality Traits	25
Chapter III. GENERALIZATIONS ABOUT FACULTY	27
CAI Developer Profile	27
Faculty CAI Developer/Facilitator Profile	30
Chapter IV. OFF-CAMPUS SHARING	
University of Kansas Medical Center	33
University of Wisconsin School of Medicine	35
University of California At San Francisco School of Medicine	37
Cornell University Medical College	37
University of Illinois-Urbana School of Basic Medical Sciences	38
University of the Pacific, Pacific Medical Center	38
Chapter V. FACULTY INCENTIVES	41
University of Illinois-Urbana School of Basic Medical Sciences	41
University of Kansas Medical Center	42
Cornell University Medical College	43
University of Wisconsin School of Medicine	43
University of California at Los Angeles School of Medicine	44
University of Alabama Medical Center	44
University of California at San Francisco School of Medicine	45
University of the Pacific, Pacific Medical Center	45
Chapter VI. EFFECTIVENESS OF MODES OF INSTRUCTION	47
Chapter VII. STUDENT PERFORMANCE	69
REFERENCES	83
Appendix A. List of Contact Personnel	85
Appendix B. University of Kansas Medical Center Student Questionnaire	91
Appendix C. List of Initializations and Abbreviations	97

Chapter I

STUDY PLAN

INTRODUCTION

A major investment in the development of a library of Computer-Assisted Instruction (CAI) materials has been made by a number of health science institutions throughout the country. This study focuses on describing and analyzing the experiences of eight biomedical CAI developing institutions:

1. University of Kansas Medical Center
2. University of Wisconsin School of Medicine
3. University of Illinois-Urbana School of Basic Medical Sciences
4. Cornell University Medical College
5. University of California at San Francisco Medical Center
6. University of California, Los Angeles, School of Medicine
7. University of Alabama School of Medicine
8. University of the Pacific, Pacific Medical Center

In a prior study (Rubin, et al., 1975) it was found that while the Lister Hill Experimental Computer-Assisted Instruction Network generated considerable interest in CAI, it was not a cost-effective method of sharing CAI materials. The study also revealed that there is need for more substantial evidence of CAI program benefits.

Many medical schools are now considering what their future plans and programs will be for CAI. It is appropriate, therefore, that this study focus on those institutions which have taken an active role in the development of CAI materials. Their experience and insights will be valuable input for administrators at these and other institutions who are now in the process of determining their long-range commitment and plans for the use of CAI.

A principal concern of this study is the impact of a major CAI development center on its own campus and, indirectly, its impact on other campuses through off-campus sharing of CAI materials. The study will provide an in-depth look at the concepts, methods and findings of the eight developing institutions and it provides a comparison of approaches across institutions.

Some of the major questions that are addressed are:

- What evidence exists that CAI improves student performance?
- How effective is CAI compared to traditional lecture/discussion modes of learning in biomedical education?
- Which CAI modes appear to be most useful for particular disciplines and areas of study?
- Are incentives offered by administrators for faculty development of CAI? Are these incentives perceived favorably by faculty? Do they work?
- What opinions are held on the value of the different modes of CAI by individuals representing different organizational viewpoints within a biomedical institution?
- What are the characteristics and attributes of students who use CAI as a major method of learning? How do they differ from their non-CAI colleagues?
- What are the characteristics and attributes of faculty who have been the prime movers for and users of CBLM? How do they differ from their colleagues?
- What are the disciplines and areas of study that best lend themselves to the use of CAI to fulfill formal course requirements? As a supplementary, optional learning resource?

STUDY METHODOLOGY

To answer the study questions, data were collected from the participating institutions. These data included descriptions of programs, instructional materials, cost data, student and faculty opinions, attributes of faculty and students, usage data, and student performance data.

A request for data pertinent to the questions being investigated was sent to each of the eight institutions. Follow-up telephone calls were made to establish personal contact and to discuss the data request.

On-site visits were made to the study institutions, during which interviews were conducted with project directors, school administrators, media center directors, computer center directors, CAI project staff, faculty, and students. (See Appendix A.) Data gathered during these visits were analyzed and gaps in the data were identified. Follow-up telephone calls were made to obtain additional information.

Data from institutions not included in the study were gathered where they would help with particular questions.

PARTICIPATING INSTITUTION PROFILE

University of Kansas Medical Center

CAI development at this institution is located within the Department of Pharmacology. The Computer-Assisted Teaching System (CATS) integrates the use of Computer-Managed Instruction (CMI) and CAI. A consortium of some 25 medical schools uses the system; some have imported the entire system while others use only selected portions. The heart of the CMI system is a test item bank containing some 14,000 questions which have been contributed by various consortium members. The CAI portion of the system consists principally of tutorials.

University of Wisconsin School of Medicine

The CAI effort at this institution is organized under the Department of Medicine with a special project staff. The project is devoted to research in simulated encounters for student instructional use and as a teaching vehicle for recertification.

University of Illinois-Urbana School of Basic Medical Sciences

The educational program at the School of Basic Medical Sciences is non-traditional in that it has a problem orientation to the teaching of the basic medical sciences. The computer is used to manage the self-guided study, and it is used as a teaching tool. The instructional materials are developed by a special staff (the Computer-based Education Project).

Cornell University Medical College

CAI development at the Cornell University Medical College is accomplished in the Laboratory of Computer Science which is part of the Department of Anatomy. The instructional units have been principally in anatomy and biochemistry and contain instructional units in gross anatomy, microscopic anatomy, and neuro-science. Programs in pharmacology are now being developed.

Cornell uses A Tutorial System (ATS) which permits the computer to simulate human discourse and facilitates the authoring process.

University of California at San Francisco

CAI activity at the San Francisco Medical Center is in the Computer Center of the Office of Information Systems. CAI materials are developed in the Programmed Inquiry, Learning or Teaching (PILOT) language. The philosophy of this programming system is that an instructor should not have to become a computer expert in order to develop a CAI program. The PILOT system can be used for traditional tutorial frame-oriented programs as well as programs providing

STUDY METHODOLOGY

To answer the study questions, data were collected from the participating institutions. These data included descriptions of programs, instructional materials, cost data, student and faculty opinions, attributes of faculty and students, usage data, and student performance data.

A request for data pertinent to the questions being investigated was sent to each of the eight institutions. Follow-up telephone calls were made to establish personal contact and to discuss the data request.

On-site visits were made to the study institutions, during which interviews were conducted with project directors, school administrators, media center directors, computer center directors, CAI project staff, faculty, and students. (See Appendix A.) Data gathered during these visits were analyzed and gaps in the data were identified. Follow-up telephone calls were made to obtain additional information.

Data from institutions not included in the study were gathered where they would help with particular questions.

PARTICIPATING INSTITUTION PROFILE

University of Kansas Medical Center

CAI development at this institution is located within the Department of Pharmacology. The Computer-Assisted Teaching System (CATS) integrates the use of Computer-Managed Instruction (CMI) and CAI. A consortium of some 25 medical schools uses the system; some have imported the entire system while others use only selected portions. The heart of the CMI system is a test item bank containing some 14,000 questions which have been contributed by various consortium members. The CAI portion of the system consists principally of tutorials.

University of Wisconsin School of Medicine

The CAI effort at this institution is organized under the Department of Medicine with a special project staff. The project is devoted to research in simulated encounters for student instructional use and as a teaching vehicle for recertification.

University of Illinois-Urbana School of Basic Medical Sciences

The educational program at the School of Basic Medical Sciences is non-traditional in that it has a problem orientation to the teaching of the basic medical sciences. The computer is used to manage the self-guided study, and it is used as a teaching tool. The instructional materials are developed by a special staff (the Computer-based Education Project).

Cornell University Medical College

CAI development at the Cornell University Medical College is accomplished in the Laboratory of Computer Science which is part of the Department of Anatomy. The instructional units have been principally in anatomy and biochemistry and contain instructional units in gross anatomy, microscopic anatomy, and neuro-science. Programs in pharmacology are now being developed.

Cornell uses A Tutorial System (ATS) which permits the computer to simulate human discourse and facilitates the authoring process.

University of California at San Francisco

CAI activity at the San Francisco Medical Center is in the Computer Center of the Office of Information Systems. CAI materials are developed in the Programmed Inquiry, Learning or Teaching (PILOT) language. The philosophy of this programming system is that an instructor should not have to become a computer expert in order to develop a CAI program. The PILOT system can be used for traditional tutorial frame-oriented programs as well as programs providing

practice with simulated clinical situations using natural language input. Instructional materials in the area of pharmacology have been developed for use on a small, stand-alone computer located in the Self-instruction Media Area.

UCLA School of Medicine

The planning for use of educational technology at this institution falls within the Office of Educational Research. There is no project group or department which has made a concerted effort to develop CAI materials. Instructional programs are developed by faculty members for use in their own teaching programs.

University of Alabama School of Medicine

CAI at this institution is a small, limited research project. CAI development took place through a special project, the Computer-Assisted Self-Assessment in Medicine (CASAM) system. The principal research effort was in the development of a simulation of a team approach to medical office practice.

University of the Pacific, Pacific Medical Center

The Model for Evaluation and Recertification through Individualized Testing (MERIT) project, supported since 1973 by the American Board of Internal Medicine and conducted at the Pacific Medical Center, is a developmental effort aimed at a model for recertification of practicing internists. The project utilizes the CASE natural language model as the examination instrument which provides simulated clinical encounters.

Chapter II

STUDENT ATTRIBUTES

Study Question:

If students using CAI have specific attributes, what are they? What characteristics of students influence their propensity to avail themselves of CAI materials?

An identification of characteristics which can be attributed to students who choose to use or not to use computer-based instructional materials can be extremely useful to medical education planners in meeting the needs of special categories of students. The answer to this question also has implications for the need to have multi-mode instructional programs.

Student characteristics which were taken into consideration include:

1. Study preferences and habits
2. Academic ability
3. Personality traits.

STUDY PREFERENCES AND HABITS

Study habits and attitudes are one of the most important non-cognitive dimensions influencing CAI usage (Anderson, 1969; Chickering, 1964; Rezler, 1975). They may be, in fact, equally or more important than personality attributes. In some situations they may act as the overriding influence; that is, a student who would tend to be a heavy CAI user because of his general disposition to self-directed study may not use the computer if it conflicts with his study habits. Study habits and attitudes include many dimensions such as:

1. Ability to work under immediate pressure of deadlines versus working best under little or no immediate external pressure. The importance of this factor was revealed at Cornell University and the University of Kansas. At Cornell, there is a great deal of pressure to attend scheduled lectures, laboratories, and study to meet the requirements of the traditional curriculum. On a student survey the overwhelming reason given for non-CAI use was the unavailability of time to use this learning resource. At the University of Kansas there is less deadline pressure. Approximately one-half of the students are enrolled in the independent study program and therefore can establish their own overall rate of learning. The students in the independent study program have 4 1/2 months in which to complete their pharmacology unit. This gives them ample time to go through the materials as much as they desire and some users spend 60 to 70 hours on the terminal. The average mean usage of students at the University of Kansas was 23 hours as compared with only 6 hours at Cornell.

2. Ability to work persistently and without procrastination versus having a tendency to delay or give up easily (Bigelow and Egbert, 1968). No data have been collected on this factor.

3. Preference for studying concrete material such as facts and practical applications versus studying abstract materials such as principles, concepts, and theory (Rezler, 1975). The CAI materials at the University of Kansas are of a highly concrete, factual nature. Several of the students interviewed indicated that they avoided using the computer for this very reason, stating that they wanted to develop an understanding of general principles, e.g., the biochemical basis of drug therapy. They faulted the CAI materials because of the emphasis on factual information and its failure to address the basis of the physiological reactions to drugs. During the interviews at the University of Kansas the high CAI users often stated that their motivation to use the computer stemmed from a

desire to achieve a "superior" grade and knowledge level of pharmacology. The best example of this is a student of average academic ability who achieved a "superior" grade and used the computer 40 hours. This student stated that CAI offered an opportunity to acquire the information necessary to obtain a "superior" grade and he felt that it was worthwhile spending the time.

The interrelationship between student learning interest and type of CAI materials as it influences CAI usage is illustrated below.

CAI Use Related to Student Learning Approach

	High User	Low User
Student emphasis on understanding principles	Complex Problem-Solving	Didactic CAI
Student emphasis on learning factual information	Didactic CAI	Complex Problem-Solving

4. Preference for teacher directed/structured study versus self-defined/student structured objectives (Rezler, 1975). There appears to be a relationship between student study objectives and preferences and CAI usage for various types of instructional materials. This relationship is depicted below.

CAI Use Related to Learning Motivation

	Auxiliary CAI	Curriculum Integrated CAI
Studies to meet instructor's criteria	Low	High
Studies to satisfy student interest	Moderate	High

If a student is interested in satisfying teacher-structured objectives to learn a body of materials (learning what the instructor emphasizes as important),

and if he perceives the CAI materials as an aid in that goal, then he will be a high CAI user. A large number of students at the University of Kansas were motivated to use the computer for this reason.

Students at the University of Illinois were not as heavy users of CAI since they perceived the materials to be tangential or supplementary to the topics being taught.

The other side of the coin is that if the student's curiosity and interest are aroused, he may make heavy use of auxiliary materials because of their intellectual challenge. This was certainly the case with the Massachusetts General Hospital clinical simulation users.

5. Preference for studying specific topics at the same time as other members of a group versus situations in which all group members are studying different things at a given point in time. This factor was not mentioned by any of the students interviewed and no data were gathered.

6. Preference for subject matter of a physical science nature versus subject matter of a social science nature (Olmstead, 1973). No distinction was made in this study.

7. Preference for studying alone versus studying with a friend or small group (Bogner, Sajid, and Clemmons, 1975; Rezler, 1975). Most students have their own study plan and interact with other students on an ad hoc basis.

8. Study habits in the areas of reading, note taking, habits of concentration, distribution of time and social relationships in study, and general habits and work attitudes. A number of the students interviewed were explicit about their reliance on reading and note taking over other methods of study. Students at the University of Illinois rely almost entirely on this method of learning. Attendance at lectures is optional; attendance seldom rises above 50% and is often much lower. There is a dichotomy between those who find textbook reading

an efficient method of learning and those who would prefer CAI because of its interactive nature. The relationship of CAI use to learning style is shown below.

CAI Use Related to Learning Style

	CAI Mode	Traditional Mode
Interactive Learning	High	Low
Passive Learning	Low	High

Time distribution and outside social relationships unquestionably have an impact upon some students. It was interesting to note that some students who have an active social calendar and who tightly schedule their time did not use the computer. They could not depend on the availability of a terminal at the time which would be convenient for them to study and the idea of waiting to get a terminal was considered a waste of time. Those who felt strongly about this made no use of the computer. Other students liked the idea of not having to attend lectures at prescribed times. A number of students at the University of Kansas worked in their pharmacology study on the computer between the lecture and lab schedules of their traditional curriculum in pathology and other areas. Because of the strong preference for CAI they were also willing to use the terminal during non-peak use periods.

9. Preference for home study versus study in a school environment. The convenience factor of home study did arise in a few instances. One of the students interviewed stated that he preferred studying at home and therefore only used the computer a couple of hours. He did use a friend's printout of the CAI materials to study for the exam. He did not find the loss of the interactive feedback to be a drawback.

University of Kansas Student Opinion Survey

From a class of 159 third-year medical students, 86 were selected to participate in a survey. (See Appendix B.) Participants were evenly divided into two categories: 43 high CAI users (with a mean terminal usage of 38.88 hours), and 43 low users (with a mean terminal usage of 9.21 hours). High and low users were randomly selected among all users having 29 or more hours of usage and 15 hours or less of usage respectively. There were 44 replies to the survey; 24 were high users and 20 were low users.

Of the students who responded to the survey, 16 indicated that the primary reason that they used the CAI materials was that it was an adjunct to studying the syllabus and a good way to review for exams. Typical comments were:

> *Material presented on CAI reviewed material in syllabus and presented it in another way which increased my learning. There was also material not in the syllabus but on CAI that was on the exams.*

* * *

> *The reason I used the CAI as much as I did was that the questions on the CAI tended to appear on the exams. I believe that the course would be much improved if a complete series of good lectures was provided. These should follow the syllabus and the syllabus itself should be re-written. It contains many errors and many confusing sections. The idea of self-directed study is good and should be retained.*

The second most frequently stated reason (11 respondents) for using the computer was that it was a good tool to measure how much material had been retained, coupled with the immediate feedback capability.

> *I appreciate most the opportunity to review a program more than once, i.e., to view a program, study on my own, and view it again. The opportunity to see my own progress was encouraging. Frequent feedback was very helpful. The CAI course unit exams were also valuable in self-assessment. None of these features can be had in the traditional lecture/lab/discussion type of course design.*

The student who made the above comment used the computer a total of 47 hours, which was well above the mean usage of 23.56 of students included in the survey.

The survey revealed that in many cases the choice of learning mode is not an either/or situation, but may include CAI, text study, etc. CAI users often have a strategy which combines several different modes which they perceive as the most effective learning approach.

> *It was an effective, easy and usually convenient way to assess my knowledge after thorough preparation from text and syllabus.*

The third most frequently stated reason (7 respondents) for using the computer was that it was an enjoyable way to learn.

> *A good, effective and enjoyable way to learn. I feel one of the essentials of learning is asking questions--and the CAI prompted me to do that for myself and asked questions of me when I didn't.*

* * *

> *CAI materials provided a totally unique learning experience which proved to be (for me) a good motivating factor in a self-directed course. The immediate feedback was also very useful especially as regards computer exams. Faculty-student discussions of exam questions were most instructive.*

* * *

> *CAI was a novel approach. Had been waiting for a chance to experiment with independent study. It is definitely more stimulating, less structured, provides a more suitable means for evaluating immediate comprehension (or lack of it) which oftentimes will impede progress if you're not aware of deficiencies.*

The three students who made the comments above were all high users, with slightly above average cognitive ability. Two of them received a grade of "A."

Preferences do not fully explain the amount of CAI usage. Five of the 16 respondents who used CAI primarily to study for tests fell into the low user category. One of the five had a negative attitude towards educational technology media:

> *Well designed and well presented lectures and labs correlated with text material remain the most effective means of instruction. As far as I'm concerned, the A-V and CAI "instruction" is simply a way to avoid truly effective teaching.*

This accounts for the fact that he used the computer for only 9 hours. He also reflected his negative opinion of CAI by ranking it as average effectiveness when compared to lectures, labs, syllabus, and textbook use.

The importance of perceptions of value can be seen by the fact that the high user group survey respondents, on a question on the effectiveness of didactic instructional methods, ranked CAI (as compared to lectures, labs, discussion groups, and A/V) as follows:

1st preference	19
2nd preference	3
3rd preference	2

If the question of factors affecting CAI usage is reversed, the question may be posed as to the attributes of students who choose not to make significant use of CAI. A graphic example is one student whose study preferences lean strongly toward reading:

> *I preferred studying at home on my own hours; and I considered CAI, from previous exposure, to be inefficient compared to my own reading. If the syllabus had not been available (and I wish it had been more comprehensive) however, I might have used CAI more for direction.*

His study approach is compatible with his verbal ability as revealed by his MCAT verbal ability score, in which he was in the 95th percentile. Of 43 students in the low user group, he ranked third in the verbal ability measure. This student considered CAI feedback as unimportant, nor did he find the self-evaluation for test preparation to be of value to him. (These reasons, feedback and test preparation, were most often given by students surveyed as their motivation to use CAI.) This student had zero usage of CAI but received an "A" course grade. Obviously, he has his own viable study approach which excludes CAI.

Another student, whose MCAT score in general information was the second highest of all students surveyed (97th percentile), commented:

> *I had compulsive worries that I wouldn't get exposed to all of the information in a particular unit if I used CAI.*

His general information score indicates that he is an avid consumer of a wide range of information. He indicated that he used the syllabus as his number one source of information and was able to get a satisfactory grade in this manner. In both of the above cases, the respondents had high academic ability and could absorb the materials in any one of a half dozen ways.

A group interview with three medical students at the University of Kansas reveals many of the factors affecting CAI usage. Student A had zero computer usage and can generally be described as a bright, articulate, assertive individual. He found that the multiple learning approach of the University of Kansas pharmacology curriculum to be highly preferable to conventional methods. This indicates that even though a student prefers independent study, he will not necessarily be a high user of CAI. Student B used the computer for 38 hours and found it to be an extremely attractive mode of learning. She was of the same general cognitive ability as student A, but was a much higher achiever in pre-medical school studies. Her personality can be described as needing frequent external approval. Student C used the computer for 27 hours and had cognitive ability which was somewhat below the average University of Kansas medical student; he was extremely hard working, with an easygoing personality. The verbatim interview with these three students follows:

Rubin: [Student A], I gather you didn't use the computer at all. Tell us why.

[Student A]: *In the beginning it seemed that the terminals were so busy that it didn't fit into my schedule regularly. I have a number of other things to do. I need to have control over my time and the computer was unavailable early in the course when lots of people were using it. I have used the printouts from the computer; I just have never used the computer terminals themselves. I had friends who had gone completely through the course last spring; so when I started it this summer I had access to the computer.printouts. I did not use them a lot; just one day a month. I did go over all the questions the computer had in some way or another.*

Rubin: You mean the review questions, self-evaluation?

[Student A]: *Right. The review questions. The computer would do a printout of a session with a student and just print it out verbatim. I would pick them up and read them over as if they were questions to see if I could answer them. If I couldn't, of course I would look to see what the right answer was. I did get feedback in that regard. For each unit I would say I used the computer programs 5 hours at the most.*

[Student B]: *You could go through the computer printouts much faster than you could on the computer itself. There was no delay, no waiting for the computer to change after you pressed the button, no waiting for the terminals. I had a hidden terminal no one used very much.*

[Student A]: *I might have used it more if I had had a terminal at home; but I'm not sure that I would have.*

Rubin: I'm not sure either. You haven't convinced me that you didn't have some other reason. I can't believe the excuse about time. How do you feel [Student B]?

[Student B]: *I believe him.*

Rubin: The terminal was available at the time but you didn't want to come over and chance the time of getting on it?

[Student A]: *Right. The real problem is that if I came over here, that's a commitment of time. If the terminal was not available then I have wasted the time I need to use to study pathology or pharmacology. What I am saying is that I would have used the computer more if it had been accessible at any time I wanted it. If I could program it into my schedule. What's important to me is that I have as much control as possible over my schedule. In medical school that's not possible. I attended almost all of my classes. I didn't attend classes in pharmacology, but I did in everything else.*

Rubin: You liked that because it's scheduled and controlled? You checked "casual" (versus "controlled") on the survey form.

[Student A]: *I attended my classes but that's not the way I would prefer it. I would prefer not to have classes at all; to have things set up. I felt that the way we were examined in medical school would behoove me to go to classes. I am a slow reader, so if I have lots of time to read I can do it. Still, if most of the material is coming out of the lectures, I'd rather go to the lectures than read the lecture notes. Then I would have time to read a textbook outside of class.*

Rubin: What did you do in pharmacology? There weren't that many lectures.

[Student A]: *I read the syllabus and the textbook. If I am going to be tested over material that comes out of the lectures, I would rather go to the lectures than read some crummy lecture notes. If I had a choice of reading good text and had the time. . . If someone were to say "Here is the material we want you to learn--just learn it whatever way you can." Supposed someone set up the course and another person was asking the questions; so that the person setting up the course didn't know what these questions were going to be. The*

only way to prepare for the exam was to look at the material and decide what you thought was important. I would prefer to have it that way because I test out well. However, when it's strictly coming from lectures, I've felt that most of our exams throughout medical school, including pharmacology, have come either from the lecture notes or the syllabus; then it behooves you to study those sources. I would prefer to use my own resources, which I would say are rather casual.

I would prefer to have less structure in the sense that the structure isn't coming from outside myself. I would like to structure the material in my own way.

Rubin: But you had a chance in pharmacology. Here is the big advantage everyone talks about in all the CAI literature.

[Student A]: That's honestly not true. There were a few times I walked in, but at the learning resources center and down here, and it was always full. That's because early in the course everyone was there. I like to be able to rely on what I'm doing to learn. I developed learning habits which enabled me to be self-sufficient. My study habits allowed me the autonomy I needed to be comfortable and do the other things I needed to do.

Rubin: You just wanted to free yourself from worrying about getting on the terminal and the computer, so you decided that would be a big hassle for you. Was it true that the terminal was so loaded you would have to wait an hour? Or was it more like five minutes that you would have to wait?

[Student B]: There were many times when I couldn't get on the terminals. As I said before there was one up on 4D which no one knew about. You weren't supposed to do CAI on it; it wasn't set up for pharmacology, but it had the pharmacology programs and the terminal was hardly used for anything else.

[Student A]: You could get in there right now from a telephone if you had the proper printout rate. I had a friend who had a terminal that would have worked a year ago, but they changed the speed of the print and hers was too slow.

I have to admit that when I first started getting computer time it was because they would say, "Look, you didn't put any time on the computer," and flunk me.

[Student B]: I had some trouble getting on the computer, so I started going during pathology lectures.

[Student A]: I skipped a few lectures, but not many. I wouldn't do it to get computer time, I couldn't see that.

Rubin: Why not?

[Student A]: After I had looked over the computer questions, I didn't feel they were that important to my learning process. I thought that the only sense that these questions were programmed in was that they were plugged into the computer. If you like answering true/false and multiple-choice questions, it's great. I don't like learning that way. If I took enough exams it would have had the same influence as the computer. I think the computer is a good idea; but it could be programmed in a more logical sequence.

Rubin: Such as. . . ?

[Student A]: *I honestly don't know because I would have to write a computer program. If you wanted me to answer that question you would have to give me a week or two to look at the computer program and decide how those questions in that particular unit could be structured so that you would be building on past lessons. I think it is possible, but I'm not sure.*

Rubin: What was your strategy for your own self-study of pharmacology?

[Student A]: *I read the syllabus once completely, then I take the exam, see how I did, read the syllabus again and go to the textbook. I would read fairly quickly, not trying to remember; when I was studying pathology, it would take about a week to read the syllabus. If I felt that my knowledge was sufficient to pass the exam that week, then I would go to the computer program and read that the day before. This would be the review for the exam. Any questions I couldn't answer I would use the textbook. Usually, I would pass the exam if I felt I was going to.*

[Student B]: *That didn't work for me at all.*

Rubin: How do you like his strategy [Student B]?

[Student B]: *I sort of do the same thing, but I never could predict whether I was going to pass the exam or not. I could never tell.*

Rubin: [Student A]: You are really managing your own instruction. Do you do that with all your courses? Come up with a strategy for each unit you must take?

[Student A]: *I usually do. I have more in the past; it hasn't been quite as easy with medical school, because there isn't much strategy in it. With the multiple-choice exams coming straight out of the lectures, you know that if you memorize the lecture notes you will pass the course. Therefore, the text reading is just for your own benefit.*

Rubin: Do you like to read the textbook?

[Student A]: *I would prefer to read the textbook. If I felt I could pass the course by just reading the textbook, I wouldn't read the class notes at all.*

Rubin: Student C doesn't even buy textbooks. Why do you [Student A] like the textbooks?

[Student A]: *I think they are better written. Textbooks are an articulate source. When you read such a source it helps you to articulate problems in the future. That is something I emphasize, being able to articulate what I see and feel about not only medicine, but about life in general. I prefer that to be the emphasis. I would rather have essay exams than multiple choice.*

[Student B]: *Yes, I would too.*

[Student A]: *In fact, the two exams I did the best on were the pathology exams. You could completely structure your own time, pot luck so to speak. You couldn't predict what you were going to get. Designing a program that was optimal, knowing you weren't aware of what you were going to get, was the only way to study for an exam such as this one. I loved the challenge. The studying was more fun and I did more reading then because of the inspiration. I generally had a good time. I also had a fantastic outline for the whole course. In a path exam, If you learn generalities, they will pay off. You also know that if you can learn a few details after the generalities about the diseases, this will pay off too. In contrast, on multiple-choice exams, you know the only thing that will pay off is a very few specific facts out of a large number of facts. What you must do is design a program of study that learns optimally a large number of facts, not necessarily understanding them. I would prefer not to learn that way. I think that it is easier to learn from generalities to specifics, instead from specifics backwards. The multiple-choice exam doesn't allow you to do this.*

[Student B]: *I would read the syllabus and the book on a particular unit. Then I would decide what I thought was important. I would take the exam and find out that what I thought was important was not. Then I would go over the exam several times and go over the computer material to see what I was going to be asked.*

Rubin: I gather you didn't depend on the syllabus like [Student A] did?

[Student B]: *Yes, it was extremely difficult for me to read the syllabus.*

Rubin: Why were they so difficult?

[Student B]: *They were poorly written, very dry; a bare bones interpretation. Very rarely would I read something in the syllabus and think it was interesting.*

[Student A]: *I felt that, too--that you couldn't pass the exams without reading the syllabus. Unless you had an inordinate amount of time to read Goodman and Gilman cover to cover, completely. That is an enormous task in the time that we had.*

[Student C]: *I knew people who did it.*

Rubin: Is it still cost justifiable to have all these different learning modes? It's costly to have the computer learning mode, lectures, a good syllabus and a good learning resource laboratory. Do you think it is essential to give the students all the choices?

[Student B]: *Yes, I do, absolutely.*

Rubin: How would you justify it? Cost-wise I mean?

[Student B]: *Students learn differently. If you want to teach medical students as much as they can learn, you must do it in different ways. It is impossible to use one mode of teaching which will be suitable for every student in the class. If you are trying to produce individuals who happen to be physicians, you have to give them some outlet for their individuality. One outlet is different modes of study.*

Rubin: Suppose I were dean of the schoool and you were coming to me. I might say that medical students are bright, we have the cream of the crop from college; they will learn this material any way we give it to them. It's a luxury the school cannot afford.

[Student C]: *I think people will learn anyway.*

Rubin: You would find some way to get this information whether or not you had this computer terminal here.

[Student A]: *I would find some way to make it. Yet, I agree with Student B to a certain extent. The more ways a student is provided with to learn, the more you are likely to have people learning the material optimally. I did learn pharmacology better than most of the other courses. I learned it well because of the freedom they gave us. I think flexibility is the keystone of their program. While I may not have used the computer and may also be critical of it, I think that overall it was a good educational program. I enjoyed it. I enjoyed this course as much as I have enjoyed any course I have had at medical school.*

[Student C]: *I can rationalize the computers; I like them. They help the students to be the best they can be.*

Rubin: Do you like those case studies?

[Student B]: *Yes, they are good.*

[Student A]: *I didn't take the case studies on the computer; I read them instead. I liked programmed learning. I used programmed learning quite a bit when I was an undergraduate in chemistry. I think it is a truly efficient way of learning. It is efficient in the way that you begin learning the fundamentals and then you work up; each page uses information you have previously had. You are not only learning new information, but reinforcing old. I think this program could work if it was planned more in this sense.*

Rubin: Would you spend money on the computers if you ran the medical school, even though you did not use the computer yourself?

[Student A]: *I might, but it would depend on the programs. I would have to read the programs. I wouldn't per se just use computer programs. A programmed text that they have now might be a more efficient use of resources than the computer itself.*

Rubin: I see. You are saying that from the dollar viewpoint, the programmed text would be chosen over the computer.

[Student A]: *Not necessarily.*

Rubin: How about the feedback? Student B likes the feedback.

[Student A]: *I don't cheat, so it doesn't make any difference. If you are trying to learn, use the tool the way it's meant to be used.*

[Student B]: *That's why the computer is good. It gives you the answer. You don't cheat and look ahead to see what the answer is.*

ACADEMIC ABILITY

In order to determine whether or not academic ability is related to CAI usage, five measures which are normally utilized in the selection for medical school entrance were considered. For each of the 86 students included in the University of Kansas survey, MCAT scores were obtained for science, verbal, general information, and quantitative ability. The overall GPA average was also considered.

The scores revealed that the high user group scored lower on all available measures of academic ability than did the low user group. Results are shown below.

MCAT Measure	Mean Scores	
	High Users	Low Users
Science	62.14	76.09
Verbal	58.49	68.53
General Information	56.84	67.72
Quantitative	61.14	70.02
Overall GPA	3.49	3.60

Accordingly, the MCAT scores and grade-point averages of the high and low user groups were analyzed by means of Multiple Discriminant Analysis, a multivariate statistical method for determining the extent to which discreet groups differ in terms of a set of continuous variables. Discriminant analysis computes

a linear transformation of the original variables to a new dimension for each group (the discriminant function), selecting weights for each original variable according to a criterion of maximizing the distance between the means of the groups on the new axis. Two statistics are returned by the analysis: the "eigenvalue," an index of the distance between the groups on the new dimension; and an "eigenvector," a series of coefficients or weights which indicate the extent to which each of the original variables contributes to the distance between the groups on the new axis. Statistical testing of the eigenvalue tells whether the difference between the means of the groups on the new axis is statistically significant. If it is significant, then the weights comprising the eigenvector can be examined to determine the relative contribution of each of the original variables.

The results of the discriminant analysis are presented in Table II-1. The data indicate that the five measures entered into the analysis do not discriminate the high and low user groups at conventional levels of statistical significance. Normally, such an outcome dictates that the analysis stop at this point--that since all variables taken together do not discriminate, interpretation of their relative contributions is not warranted. Nevertheless, given the exploratory nature of the present study, the raw values of the eigenvector are presented along with normalized values for each. Comparison among the original variables is made in terms of the normalized eigenvector, and interpretation is made with respect to the group having the higher mean value on the new axis. There is, further, no statistical test available for evaluating the significance of the normalized weights; the current "rule of thumb" is to interpret the largest weight and any others which are at least half its size. Accordingly, these data suggest that the single characteristic distinguishing most clearly between the

Table II-1. Results of Multiple Discriminant Analysis of MCAT Scores and Cumulative Grade-Point Average for High and Low Computer User

1.	Means for groups on new axis:	High Users: 24.54	Low Users: 29.47
2.	Weights for original variables (eigenvector):	Raw	Normalized
	MCAT Variable	.034	7.36
	" Quantitative	-.036	-7.85
	" General Information	.067	15.46
	" Science	.283	47.40
	Cumulative GPA	.956	3.78
3.	Index of distance between groups (eigenvalue): .172	Bartlett's Chi Square test = 6.116, df = 5; .20 < p < .25	

groups is score on MCAT "Science," since the low-use group has the higher mean on the transformed axis (cf. Table II-1, Part 1). We conclude that they are characterized as being higher on this aptitude. This finding corresponds with the actual difference obtained between the means for the two groups (cf. Table II-2).

Table II-2. Means, Standard Deviations and Tests of Significance of MCAT Scores and Cumulative Grade-Point Average for High and Low Users

	High Users		Low Users			
MCAT SCORES	Mean	s.d.	Mean	s.d.	t	p
Verbal	58.95	25.48	69.93	24.11	-1.85	.06
Quantitative	61.14	23.27	67.71	22.62	-1.32	.19
General Information	56.84	28.49	68.38	21.61	-2.10	.03
Science	62.14	21.24	76.10	14.89	-3.50	.0008
Cumulative GPA	3.49	0.49	3.61	0.36	-1.20	.23

Throughout the present section, the data have strongly indicated that the low-use group is generally brighter and has better academic records than the high-use group. Data presently available do not permit any firm conclusions concerning why the better students did not avail themselves of more of the CAI materials which, as has been shown, contributed significantly to the overall grades in the low-use group (who were generally not as capable). It might be tentatively suggested that the brighter students, accustomed to consistent academic success via their own methods of study, did not view the computer-based materials as particularly necessary or important to obtaining a good grade in pharmacology--especially in light of the fact that such study was on their own time.

It has been observed during the conduct of the study that students with high academic ability tend to make heavier user of computer simulation than do students of lower ability. Dr. Richard Friedman at the University of Wisconsin School of Medicine indicated that the brightest students were the ones who came back repeatedly to work up the clinical simulation cases. The chart below portrays the relationship between the type of instructional materials and academic ability as it affects usage.

CAI Use Related to Academic Ability

	High Usage	Low Usage
High cognitive ability	Complex problem-solving	Tutorial
Low cognitive ability	Tutorial	Complex problem-solving

Data from the schools visited during this study were unavailable to support the thesis that the better students make more use of clinical simulations than do the less academically gifted.

PERSONALITY TRAITS

The question of whether or not there are personality factors which affect computer usage has been raised. Is there any particular personality profile that describes the typical CAI user?

Personality traits such as assertiveness, independence, casualness, and anxiety level were considered. In interviews with students, anxiety level appeared to be an important factor in computer usage. Those students with a high level of anxiety used the computer to evaluate their progress and thus alleviate anxiety about their knowledge level.

At Ohio State University a study was made of personality traits in which students who chose to participate in an independent study program were compared to students who chose the traditional group instruction program (Griesen, 1971 and Folk, et al., 1976). The independent study program included computer self-evaluation programs in all areas of basic medical science subjects.

Four standardized psychological instruments were used in the study.[1] A number of personality factors were identified in which the independent study students differed significantly from the group instruction students. The independent study students were found to be more assertive (vs. humble), more experimenting (vs. conservative), and more independent (vs. dependent), but at the same time they were more reserved (vs. outgoing) than were those students preferring group instruction. The students choosing independent study had a lower anxiety level than those choosing group instruction.

---

[1] (1) Sixteen Personality Factor Questionnaire; (2) Opinion, Attitude and Interest Survey, (3) Omnibus Personality Inventory; and (4) Meyers-Briggs Type Indicator.

No conclusions can be drawn from the OSU data with regard to CAI usage since students who participated in the independent study program used the computer and those in group instruction did not.

Students surveyed at the University of Kansas were asked to complete a personality profile rating scale (See Appendix B). The results indicate that there was no significant personality difference between those students who were heavy CAI users and those who used the computer for a relatively low number of hours.

Chapter III

GENERALIZATIONS ABOUT FACULTY

Study Question:

Can any generalizations be established about the types of faculty involved in developing CAI materials? What are these faculty attributes?

A significant range of strategies and approaches to CAI development became apparent during the conduct of this study. This, in turn, affects the makeup of participants. Examples of various strategies used to produce computer-based instructional materials follow.

1. One developer school did not use faculty members as developers but chose to hire a staff of content specialists.

2. The development team approach was used at another school where faculty served in an advisory capacity, and materials, for the most part, were authored by research assistants using a pre-determined script format.

3. Another approach was to employ student authors to develop a large portion of that school's materials under the supervision of departmental faculty members.

4. Faculty departmental specialists wrote the CAI materials at another institution, with each developer focusing on his area of expertise.

5. Still another school used an educational researcher with a background in CAI development and psychology as the author.

CAI DEVELOPER PROFILE

To characterize CAI developers, inquiries were made as to professional discipline and/or education. The results are shown in Table III-1. When the study was first instigated, it was hypothesized that:

- Faculty members who hold PhDs in scientific disciplines make up the majority of CAI development participants.

CAI DEVELOPER PROFILE

	DISCIPLINE/EDUCATION						NUMBER OF ITEMS DEVELOPED BY:			
	PHD in:									
	Science Discipline	Psychology/ Education	M.D.	D.D.S	Research Assistant Instructor/ Resident	Medical Student	Faculty	Students	Special Staff	Research Assistants/ Residents
University of Kansas	6	0	5	0	0	6	65	5	0	0
University of Illinois	3	1	2	0	0	0	1	0	120	0
University of California, Los Angeles	2	0	8	0	3	0	28	0	0	3
Cornell University	1	1	3	1	0	15	14	35	0	0
University of the Pacific	0	1	2	0	2	0	5	0	0	10
University of California, San Francisco	2	0	1	0	0	0	8	0	0	0
University of Wisconsin	0	0	1	0	0	0	25	0	0	0
University of Alabama	0	1	0	0	0	0	1	0	0	0
TOTALS	14	4	22	1	5	21	149	40	120	14

Table III-1

Of 67 participants, only 14 fell into this category. They did, however, outnumber those with PhDs in educational or psychological disciplines.

During our inquiry, it became obvious that there are a significant number of CAI developers who are not members of the faculty (29 of the 67 were so identified). These non-faculty developers (medical students, residents, special staff members, and research assistants) accounted for a significant portion of the CAI materials developed, as shown in Table III-1.

The largest group of non-faculty developers is medical students. Dr. John Doul at the University of Kansas Medical Center commented that programs developed by students at that institution were of excellent quality and that these students, because of their dual role as users and developers, were in a better position to know how to design the materials to be of maximum benefit to their fellow students. There are plans to significantly expand the role of students in the development of CAI at the University of Kansas during the 1976-77 academic year.

Cornell University makes heavy use of student developers. This group represents approximately 3/4 of the total number of developers at that institution.

Quantification of Items Developed

To gain a perspective of the relative productivity of the various types of developers, it can be observed that 39 faculty members produced a total of 149 units, while a special staff of four content specialists, who are not members of the faculty at the University of Illinois, produced nearly as many units. Thus, even though there was a great deal of interest and enthusiasm on the part of many faculty members, they were unable to produce as many CAI items as did the special staff who devoted their full efforts to this endeavor.

Other factors, of course, would influence development time such as: ease of CAI language usage, availability of release time from regular duties, and so forth.

FACULTY CAI DEVELOPER/FACILITATOR PROFILE

It is useful to take a closer look at the characteristics of those faculty members who have developed CAI materials. Table III-2 shows a breakdown of attributes which, we believe, have a bearing on who participates in technology-based instructional development projects. Also included are those faculty members who did not actually develop materials, but acted as facilitators or technical advisors. The attributes are:

1. Faculty position
2. Developer age
3. Tenure status
4. Prior CAI experience
5. Prior teaching experience
6. Primary professional focus

For each of these characteristics a hypothesis was selected for investigation.

Faculty Position

- Low-level faculty members (instructors and assistant professors) have a larger role in CAI development than do high-level faculty (full and associate professors).

The study revealed that faculty participation is dominated by senior faculty; 32 of 39 faculty participants were either full or associate professors.

Developer Age

- Faculty members who are under the age of 40 are the predominant participants in CAI development.

The over-the-hill gang won out! Of the 39 faculty participants, 2/3 are over the age of 40. A large number of the developers fell into the age bracket of 40 to 45 years of age.

FACULTY DEVELOPER/FACILITATOR PROFILE

	Position				Age		Tenure		Yrs. CAI Exp.		Yrs. Teaching Exp.		Primary Professional Focus		
	Full Prof.	Assoc. Prof.	Ass't Prof.	Instructor	Under 40	Over 40	Yes	No	Under 2 yrs.	Over 2 yrs.	Under 15 yrs.	Over 15 yrs.	Sci. Res.	Educ. Res.	Teaching
University of Kansas	8	1	1	1	4	7	9	2	2	9	5	6	6	0	5
University of Illinois	1	0	1	0	1	1	1	1	0	2	1	1	0	2	0
University California L.A.	6	5	0	1	3	9	9	3	7	5	4	8	9	3	0
Cornell University	3	3	0	1	2	5	5	2	2	5	3	4	4	2	1
University of the Pacific	2	0	0	0	0	2	0	2	1	1	2	0	1	1	0
University California San Fran.	3	0	0	0	1	2	2	1	0	3	1	2	1	1	1
University of Wisc.	0	0	1	0	1	0	0	1	0	1	1	0	0	1	0
University of Alabama	0	0	0	1	0	1	0	1	0	1	1	0	0	1	0
TOTALS	23	9	3	4	12	27	26	13	12	27	18	21	21	11	7

Table III-2

Tenure

- Untenured faculty who are not committed to traditional teaching methods are the predominant participants in CAI development.

Our investigation revealed that over 2/3 of faculty participants hold tenured positions. We speculate that tenured faculty have less reason to be concerned about the proclivities of their departmental chairmen and are thus more willing to experiment with alternative instructional modes.

CAI Experience

- Prior experience with computers in instruction is a prerequisite of participation.

This hypothesis was supported. Of the 39 faculty participants, 27 have over two years' experience with CAI, and many of these have experience of 10 to 15 years.

Teaching Experience

- Faculty members with under 15 years' teaching experience are the predominant CAI development participants.

To the contrary, the majority of faculty participants have substantial teaching experience.

Primary Professional Focus

- Teaching or educational research, rather than scientific research, is the primary professional interest of most CAI development participants.

The study revealed that 21 of 39 faculty participants have scientific research as their principal interest.

Chapter IV

OFF-CAMPUS SHARING

Study Question:

How was off-campus sharing accomplished? What problems were encountered with sharing CAI materials and how were they solved? What provisions have been made for user modification and feedback to the original programs?

The CAI developer institutions differ widely in their configurations and in their efforts to facilitate sharing.

THE UNIVERSITY OF KANSAS MEDICAL CENTER

The University of Kansas has two types of systems to be shared. The CAI programs are written in Coursewriter and the CMI[1] programs in COBOL. The programs for both systems were written for an IBM 370/145 configuration.

The mechanism for sharing is the CATS Consortium, made up of approximately twenty medical schools. All members are furnished with a copy of the program library on tape and printed cards containing test item questions associated with the CMI system.

The precise method by which sharing is accomplished varies from institution to institution depending upon computer configurations. Michigan State University, currently operating with a CDC 6600, implemented only the CMI portion of the curriculum. Since these programs were written in a high level language (COBOL), there was no problem with converting them to the Control Data computer. Because Coursewriter is not available on the CDC 6600, the CAI materials have not been used.

---

[1] Computer-Managed Instruction (CMI) involves examination development, examination scoring, student evaluation, course evaluation, and other aspects of course administration.

No modifications were made to the CMI system by Michigan State University. However, MSU made a significant contribution to the data item bank; 30% of the questions in the current item bank originated at MSU. Dr. Ted Brody at Michigan State stated that they have plans to obtain a Hewlett-Packard minicomputer for Department of Pharmacology use. Selected University of Kansas CAI materials will be manually translated into H-P CAI language.

Jefferson Medical College in Philadelphia, Pennsylvania, imported both the CAI and CMI programs from KUMC. Jefferson, fortunately, had an IBM/370 computer; thus, there were no hardware compatibility problems. However, the Coursewriter language was not available on the school's computer. The solution was to use some of the earlier Kansas versions of the materials written in COBOL and Assembler languages. Although there are a total of approximately 90 CAI programs, only 40 were in the original language. Program modifications were handled by the computer center staff. Twenty to thirty thousand dollars was spent for initial system conversion, primarily for systems analysis time. Jefferson's pharmacology faculty has written 8 to 10 of their own CAI tutorials in COBOL and Assembler. Kansas has taken these programs and manually translated them into Coursewriter and has made that version of the programs available to the CATS Consortium.

While most of the Consortium members imported the CMI portion of the system, the University of Illinois chose to import only the CAI portion. Since Illinois has the PLATO system which uses the TUTOR language, it was necessary to accomplish the translation manually. However, this posed no special problem and was accomplished by students in approximately three weeks. Illinois has made no modifications to existing CAI materials or developed any new ones. The CMI portion was not imported because it would not fit into the overall scheme of student examinations.

System compatibility problems are a factor in limiting the sharing of Kansas CAI materials, although the obstacles can be overcome through manual translation if the receiving institution is willing to make a commitment.

THE UNIVERSITY OF WISCONSIN SCHOOL OF MEDICINE

The computer-based simulation system at the University of Wisconsin is programmed in FORTRAN IV and is currently operated on a UNIVAC 1110. Since FORTRAN IV is a high level language, available on most computer configurations, there are no major differences in dialect between various FORTRAN IV implementations.

Duke University School of Medicine is in the process of converting the programs from UNIVAC to an IBM 371/65. There are plans to place the simulations on a minicomputer, in which case considerable re-programming will be required. Dr. Steven Truss plans to modify the system to include the psychological aspects of a clinical encounter. He also plans to expand the overall programs to include the prescription of treatment after diagnosis is made.

Loma Linda University School of Medicine has imported the Wisconsin clinical simulation system. The system was converted to run on a Data General Nova minicomputer, using time-sharing BASIC language. A medical school student spent 2 1/2 months working, in his spare time, to convert the system. The total cost was under $1500.

The clinical cases available from Wisconsin were adapted to the local situation; that is, laboratory schedules and fees. The system was implemented as designed by Dr. Richard Friedman at Wisconsin, but several small conveniences were added to facilitate case authoring. A development effort of 100 cases in a wide spectrum of specialties (e.g., cardiology, renal disease) was planned because the junior medical students do not have access to patients. A total of 40 cases were actually developed, with 15 to 20 of these being in the area of hematology.

All students were required to attend a laboratory where they work in groups under the guidance of an instructor. The instructor steers the students on their selection of laboratory tests to be given. From the teaching angle, the value of the laboratory is that the learning cycle is shortened. Normally, with a real patient, it will take three days to a week for tests to be ordered, results to be obtained, and the case to be discussed with the students. This is collapsed to a few minutes, using a synthetic patient via a computer.

Dr. Bryan Bull, Chairman of the Department of Pathology at Loma Linda, stated that the time to develop a case, that is, to abstract the required data from a real case, was only a few hours. It then takes only 1/2 hour to an hour for the case to be entered into the computer. A secretary was used for this latter task, following a standard patient-physician protocol. Approximately a week was required to enter the data on the laboratory tests including the normal values, test cost, and scheduling time.

The question was posed as to whether Loma Linda had made the new cases available to the originating institution, Wisconsin. Dr. Ivan Nielson, Chairman of the Department of Biomathematics, said that the development of cases was thought of as a local effort and they had never really considered the idea of sharing the cases with other institutions. However, since the MUMPS language has recently been standardized and is available on the Nova, Dr. Nielson expressed an interest in putting the cases up under a MUMPS system. Because of the widespread interest in and use of MUMPS, with its cost-effectiveness advantage, this would greatly facilitate the interchangeability and sharing of programs. Dr. Bull stated that there was no overt reason for not giving the cases to Wisconsin, it simply hadn't yet been done. He obtained the cases by happenstance while travelling through Wisconsin. He stopped at the Medical School, talked with Dr. Friedman, and obtained them. He has heard through the grapevine about the expansion of Wisconsin's

system to include cases where students manage patients and prescribe treatment, and is considering contacting Dr. Friedman about obtaining these new cases.

The Baylor University School of Medicine obtained the Wisconsin system and converted it from the UNIVAC 1110 to the IBM 360, using a student who had had some prior experience with computers. It took several months to accomplish the conversion to PL1 under OS from FORTRAN IV under ATS. Three or four of the Wisconsin cases were loaded onto the system but the project died after a few demonstrations.

UNIVERSITY OF CALIFORNIA AT SAN FRANCISCO SCHOOL OF MEDICINE

This institution's sharing efforts have been primarily in the area of the development and standardization of a language to operate on small computers rather than on the sharing of the few instructional materials that have been developed. The PILOT language operates on an intelligent terminal (Datapoint 2200) which has a built-in minicomputer and uses tape cassettes for auxiliary storage. Sharing is facilitated by the convenience and ease of maintaining a library of cassettes on various instructional topics. In order to assist the creation of a library of materials, a Coursewriter-to-PILOT translator program has been developed.

CORNELL UNIVERSITY MEDICAL COLLEGE

Cornell uses the Telenet network. Cornell is also converting to VS APL, as supported under VSPC, IBM's newest interactive APL system. These steps should remove what has for the past three years been a major impediment to sharing--the non-standard version of APL under which Cornell was operating.

Prior to the four years of non-standard APL, when Cornell did have standard APL, the ATS system itself was provided to a number of schools including the University of South Florida, SUNY--Binghamton, and the University of Hawaii.

There has been one attempt to manually translate the CAI tutorials from APL to TUTOR. One program was translated but it was felt that the translation was lacking since it did not contain the instructional strategy which is integral to the ATS system. The translation to TUTOR used a text question-answer format, but did not have the student system interaction of the original version.

UNIVERSITY OF ILLINOIS-URBANA SCHOOL OF BASIC MEDICAL SCIENCES

The University of Illinois uses the PLATO network. The network itself provides the physical communications between network users. Authors from one school may "talk" with authors from other schools, and access publicly available materials. The PLATO network user community currently consists of eight medical schools.

UNIVERSITY OF THE PACIFIC, PACIFIC MEDICAL CENTER

The MERIT project at this institution is a research and development effort to design a recertification model for the American Board of Internal Medicine. The materials are not designed for student use, however, they are used by graduate medical students as they are available through the Health Education Network.

The CASE natural language computer model (Harless, et al., 1973), which the MERIT project utilizes, has been moved from one environment to another. CASE was originally developed at the University of Illinois College of Medicine in Chicago, and was later transported to OSU. CASE was written in Coursewriter III, a language supported by IBM. The significant aspect of CASE is that it is programmed to understand and respond to any English language inquiry that relates to the medical and sociological background of the patient being simulated.

In order to facilitate the development of a library of cases, a semi-automated case generating system (known as GENESYS) is used (Harless, et al., 1973). GENESYS allows the author to respond to questions asked by the computer.

The CASE system is available to a large number of graduate medical students through the Health Education Network Users Group (HENUG).

The MERIT project staff has worked in cooperation with the OSU staff which is maintaining the CASE system--creating new courses, field testing and refining materials, and recommending refinement to the system's programs. This cooperation has been extremely productive for both the host institution and the user group.

Chapter V

FACULTY INCENTIVES

Study Question:

If incentives for faculty development of CAI have been offered, what are they and have they proven effective?

In this study a search for definitive faculty incentives for participation in CAI development was made. Some of these were:

1. Personal interest in teaching innovations.
2. Release time from teaching/research responsibilities.
3. Royalty income.
4. Promotion credits.
5. Recognition for educational research.
5. Salaries for development of CAI materials.
7. Departmental/administrative support.
8. Board sponsorship.

The payment of salaries, as might be expected, proved to be the Number 1 incentive. This method produced 120 instructional units at the University of Illinois School of Basic Medical Sciences.

Some elements of the other incentives were apparent at other institutions.

UNIVERSITY OF ILLINOIS-URBANA SCHOOL OF BASIC MEDICAL SCIENCES

It was originally planned that the faculty members at the School of Basic Medical Sciences would develop the CAI materials. This did not work out, since faculty members were devoting all of their efforts to the development of a new curriculum.

The basic sciences at Illinois are taught in the context of clinical problems. The new curriculum consisted of actual patient case histories which are used as examples of specific diseases that demonstrate interdisciplinary principles. The major product of this new curriculum was the development by the faculty of a comprehensive study guide.

Since the faculty members were devoting all of their time to the new curriculum, it was determined that a special CAI development staff would be needed. In 1973 the first member of the staff was hired and subsequently the staff was expanded to a total of four. The incentive for development, therefore, is a full-time, salaried position.

Up to this point, there was no incentive for the faculty to become involved with the computer-based instructional development. The gulf between the faculty and the CAI developers was a negative factor in acceptance of CAI in the school. Recently, however, this problem has been alleviated in that the faculty are now acting as consultants on instructional module objectives and review of the modules. Thus, a psychological incentive has been created for faculty participation. Some faculty members have taken the initiative to suggest topics where the current curriculum is deficient and CAI would be of assistance to fill the gap.

UNIVERSITY OF KANSAS MEDICAL CENTER

The outstanding incentive to encourage faculty participation in CAI development at this institution is the strong advocacy of the chairman of the Department of Pharmacology. Thus, promotion and recognition are available to faculty members and this incentive's success is demonstrated by the large number of units which have been produced by the Department of Pharmacology. Also, the faculty has received additional recognition in that their department has been annually voted "best teaching department" by the students.

CORNELL UNIVERSITY MEDICAL COLLEGE

At Cornell there is a supportive environment for CAI development. Staff support is available to help faculty members learn how to use ATS. However, there are no special incentives for encouraging faculty contribution. Dr. W.D. Hagamen, a major faculty contributor, stated that incentives were non-existent; faculty are not released from their teaching and research responsibilities, they do not score points with the administration for developing CAI lessons, and they are not promoted based on CAI development work. Nevertheless, the faculty members have written 14 instructional units.

The Number 1 incentive at Cornell appears to be stipends paid to students for a summer assistantship during which they author CAI programs. Over 3/4 of Cornell's instructional units have been developed in this manner.

UNIVERSITY OF WISCONSIN SCHOOL OF MEDICINE

The primary incentive at the University of Wisconsin for the development of materials is the research support attained for work on the use of patient-physician simulations as an evaluation instrument. The Department of Medicine faculty apparently have no incentives to participate in case development and Dr. Richard Friedman has developed all of the cases (25) that are currently available.

The Chairman of the Department of Medicine generally supports Dr. Friedman's work, but he has not taken an active interest in the development, nor has he attempted to integrate the cases into the teaching program.

Dr. Friedman's personal incentive for participation is his great interest in the area of clinical problem-solving. He envisions an important future for the simulated clinical encounter for recertification.

UNIVERSITY OF CALIFORNIA AT LOS ANGELES SCHOOL OF MEDICINE

At UCLA, there is no program for encouragement of faculty participation in CAI development. Nearly all of the units developed at UCLA are the result of faculty interest and were produced in addition to the developer's regular responsibilities for teaching and research.

There is no CAI development organization such as that found at Cornell, Illinois and Kansas. Further, programs have been developed in many different areas, with no concentrated effort in any particular medical discipline.

At the moment, there are disincentives for authoring CAI materials at UCLA. The primary emphasis is on research, and students are expected to follow in this mode.

UNIVERSITY OF ALABAMA MEDICAL CENTER

The CASAM project at the University of Alabama was directed by Dr. Charles Slack. The project was funded by sources outside the university, and participation by students and faculty was voluntary.

Because of a lack of faculty and administrative interest, the CASAM project is dormant at this point in time. Dr. Slack is no longer associated with the University, and he has not been replaced. No incentives were offered at this institution, and CAI's existence there was due a most entirely to Dr. Slack's interest. In the nearly total absence of faculty and administrative support, the project was unsuccessful, even though the materials were of good quality. Here, as at UCLA, the incentives were negative.

UNIVERSITY OF CALIFORNIA AT SAN FRANCISCO SCHOOL OF MEDICINE

Personal interest of individual faculty members in experimenting with new teaching methods was the principal factor in the development of the pharmacology CAI materials at this institution. In all of the schools included in this study it was observed that when this is the only incentive the materials are sparse and do not become a significant factor in the curriculum. An established project with administrative and funding support such as that found at Illinois, Cornell, Kansas, Pacific, Ohio State University, and Massachusetts General Hospital will produce a meaningful library of materials.

UNIVERSITY OF THE PACIFIC, PACIFIC MEDICAL CENTER

The University of the Pacific is a special case, since the MERIT project is not concerned with students, but with the development of a model for physician recertification. The authors of CASE materials for this project are selected for their expertise in areas of internal medicine and have been recruited from a variety of sources--including members of the American Board of Internal Medicine, faculty in the Department of Medicine at Ohio State University, and practicing internists in San Francisco.

Chapter VI

EFFECTIVENESS OF MODES OF INSTRUCTION

Study Question:

Which modes of CAI instruction have the institutions chosen to emphasize in their programs? Do data exist on their effectiveness vs. the effectiveness of traditional teaching and testing methods? Which mode is most effective in the opinion of the learning resource center or library, the dean, the departmental chairmen, the curriculum committee, the individual teaching faculty members?

UNIVERSITY OF THE PACIFIC, PACIFIC MEDICAL CENTER

CAI development at the University of the Pacific is centered on evaluation of practicing internists. The MERIT project was initiated in July 1973 and was successfully piloted with 29 board-certified practicing internists in San Francisco.

The philosophy of the project is that periodic evaluation, which can contribute to continuing education, is most effective if it is relevant to the practitioner's everyday experiences. To meet this criterion, data were collected from participating internists which describe the kinds of patients and patient problems that these physicians encounter daily. The physicians maintained diaries about their practices in terms of complaints and diagnoses, as well as sociological data. Each diary was then abstracted into a practice profile. Using the profile data, each practitioner's examination was individualized.

A central aspect of the MERIT model is the use of computer simulation of the physician-patient encounter. This is accomplished with the CASE system; the examination instrument for the individualized evaluation.

The CASE system was designed to allow the role-playing physician to gather data from a complete body of medical information (medical and sociological history, physical, laboratory) in an independent, unconstrained and undirected manner, and to make determinations about diagnoses and medical intervention.

(See Figure VI-1.) It is, therefore, a model which can assess the quality of a candidate's independent decision-making and problem-solving acumen.

During the San Francisco pilot test, the average completion time for three cases was 3 hours 20 minutes. Immediately following the examination, the 28 internists filled out a questionnaire. The results were:

- 93% rated the case simulations as an appropriate and desirable testing mechanism for recertification.
- 88% felt the cases in their exam were representative of the patients in their practice.
- 82% felt that the cases were similar to their behavior with actual patients.

In terms of simulation realism one measure is the ability of the system to respond to unstructured questions. The average response rate for the various cases was between 90 and 96%. This means that the computerized patient was able to make an appropriate response to the physician's inquiries in nearly every instance, which indicates that the cases are highly refined.

A second pilot test of the MERIT model with practicing internists in the State of Ohio has been recently completed and data are available from the MERIT project.

UNIVERSITY OF ILLINOIS SCHOOL OF BASIC MEDICAL SCIENCES

This institution uses several instructional modes:

1. Gaming,
2. Laboratory simulation, and
3. Tutorial,

sometimes in combination with each other. During a simulation, for example, it may become apparent that the student does not know how a particular hormone or

History

Is your father still alive?
Both of my parents are still living. . .

How is your father's health?
Generally speaking, my father is not in very good health. I don't know. . . he had a heart attack 8 years ago, and he has cataracts, too. He also has high blood pressure, gout and diabetes.

How is your mother's health?
My mother is in generally good health except that she has psoriasis. She has had it for many years.

Do you have any problem with your vision?
I'm extremely nearsighted. It's so bad, in fact, that I almost didn't get into the Army. . . they let me in, though.

Physical Examination

General appearance
The patient is short, obese, acne-scarred and has a melancholy appearance. He is in no acute distress.

Abdomen
Abdomen (inspection)--Increased girth, distended with slight flank bulging. Dilated veins visible, distended with normal flow pattern. A well-healed 6 cm. scar in right lower quadrant. No other abnormalities.

Palpate Abdomen
Abdomen (palpation)--Minimal abdominal tenderness with non-localized rebound. No masses felt. Palpable fluid waves present. Spleen, kidneys not palpable. Liver palpable 3 finger breadths below right costal margin. No evidence of hernia.

Laboratory

Fasting Blood Sugar
Fasting Blood Sugar: 160 mg/100 ml

BUN
Blood Urea Nitrogen: 40 mg/100 ml

Figure VI-1. Excerpts from a Physician-CASE Interaction

organ works. The student may be asked a series of questions in the fashion of a tutorial to penetrate his understanding of the problem. A student can be asked questions about the problem he is facing about the patient's problem. He is thereby given assistance with his diagnosis.

In a gaming situation, students compete with one another in the identification of chromosomes. The game does not require all contestants to be present at once. The game is ongoing, and each student may "play" as often as he wishes whenever he wishes. He can request his standing in the competition at any time. Students also have the option to merely take the exercise without competing.

In one exercise the student plays the part of a clinical geneticist. A case is randomly presented to him among the following types.

1. Normal female
2. Normal male
3. Turner's syndrome
4. Klinefelter's syndrome
5. Trisomy X
6. Down's syndrome
7. Patau's syndrome
8. Edward's syndrome
9. Philadelphia syndrome

The student determines the patient's clinical problem or suspected diagnosis. An example display of the chromosomes for karyotyping is shown in Figure VI-2. The student touches the chromosome and then touches the box into which he thinks it goes.

This exercise allows practice in genetic karyotyping. A number of the chromosomes are similar in appearance, and repeated observation is helpful to

m122/tp

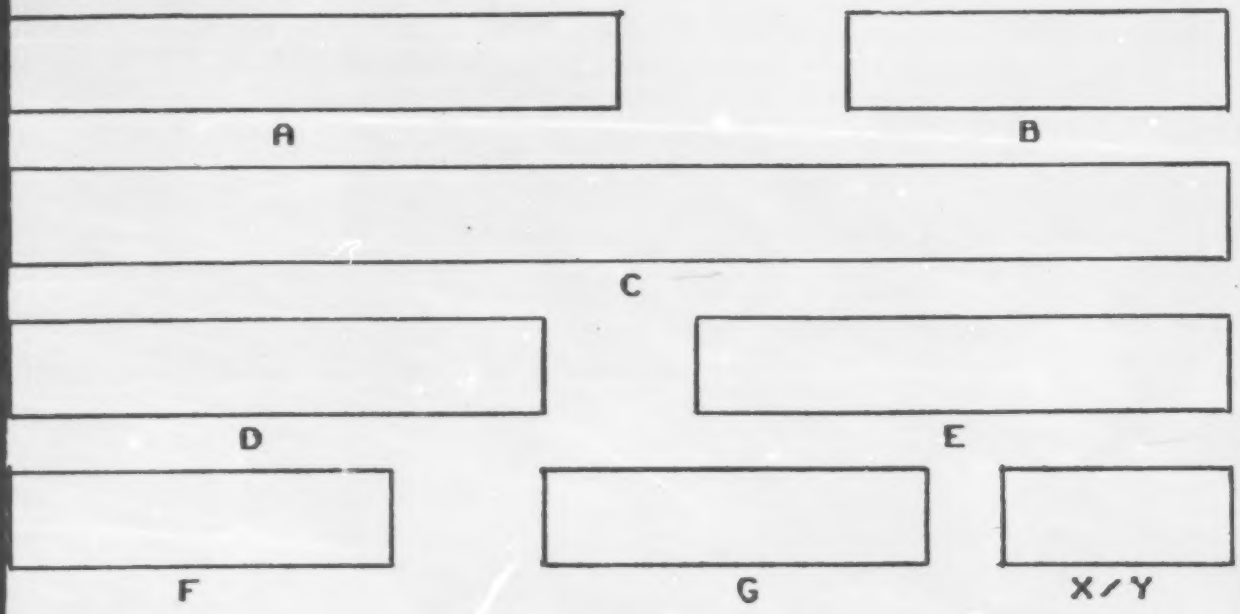


Figure VI-2. Karyotyping Chromosomes

build skills. If a wrong identification is made the computer indicates the correct choice.

There was no data available to prove that this mode is more effective than a lecture, but it is certainly difficult to duplicate this exercise on a blackboard.

Dry lab simulations are another mode of instruction. An example is the simulation of cardiovascular effects of chemical agents. A student may want to observe the effect on blood pressure with the injection of a saline solution. An agent can be injected which will have an interaction with other agents already dumped into the system. The student may be asked to figure out what other agents are present in the blood stream. The laboratory simulations encourage the student to set up proper experimental controls. The output of the "experiment" is a plot that shows the changes that occur in the system; e.g., increase in blood pressure.

Unfortunately, there is no data on this mode's effectiveness; however, it has certain advantages when compared to a wet lab. Each student individually conducts his experiment, while in a wet lab he would normally be working in a group. Also, a student is given "personal" attention and can immediately see his errors.

Currently, this dry lab is used just under 50 times per month (there is no data on how many student users this represents).

UNIVERSITY OF WISCONSIN SCHOOL OF MEDICINE

Like the University of the Pacific, Wisconsin's focus is on simulation of the patient-physician encounter. The simulation system uses a dynamic model where the patient's condition changes over time. All test results can change

hourly depending on the patient's condition, effects of treatment, or disease course. The model is designed so that the house staff treats the patient symptomatically and while their treatment may not be correct, it is intended to prolong the patient's life until a diagnosis has been made.

Under the model's rules a student cannot alter the "patient's" treatment, but he must be cognizant that the treatment will affect the patient's condition and the results of the tests. The student-doctor, as the diagnostic consultant, is asked to make a definitive diagnosis. (There is no provision for a differential diagnosis in which the attending physician rules out certain conditions as he does the workup.) The model does not provide for treatment after diagnosis.[1]

The results of over 2,000 tests are included in the scripts. The tests can be ordered STAT (emergency) or are made available on a normal hospital time schedule. The system also includes nurses' notes that are generated spontaneously by the system. They notify the "doctor" of any change in the patient's condition and indicate all medications prescribed by the house staff.

There is a provision for the "doctor" to observe the patient for different time periods (by advancing the clock) to learn about any changes in patient condition or medication. If an incorrect diagnosis is made the "doctor" is penalized in time and money in an amount corresponding to how serious a missed diagnosis would be at that point of the patient's illness. During the time penalty, the "doctor" cannot order tests, but will receive nurses' notes and the results of all tests previously ordered.

---

[1] A new model has recently been developed that includes therapy, where the patient's condition changes and results are observed.

The effectiveness of this system must be evaluated against two purposes:

1. As a diagnostic teaching system, and
2. As a testing system for measuring clinical competence.

Diagnostic Teaching System

A survey of third year medical students (1974-1975) showed that, in their opinion, the system was effective. Of 131 questionnaires, 53 were returned. There were 104 CAI users in this group of 131. The results shown in Figure VI-3 indicate that the students gave the system high marks. They see simulations as useful for self evaluation and gaming experience. Only a slight majority (25 yes, 22 no) were interested in being tested by a simulated patient encounter. They also felt doubtful about whether the simulations reflected their performance on the floor. These doubts may have been caused by misconceptions about the operation of the model. For example, several students were unaware that all physical findings not reported by the computer were to be considered as negative (i.e., not present in the patient).

Student survey comments were mixed:

Positive

Good teaching tool!

I had a very difficult time learning how to make the computer work for me (i.e., getting the program started took me 45 minutes). Once I got started there were only minor technical difficulties like running out of paper. Only about 1/2 hour of my initial 2 hours was spent learning medicine, the rest was frustrating computer work (technical). On a return visit, once I knew how to make things work, I thought that the computer program was useful.

This tool is excellent for helping me formulate dd (differential diagnosis) and evaluation of the patient. It is so good, I think it might be expanded and required to be done once a day for 1 hour; if the machine could be kept up better.

I would like to see the evaluations of the various programs available regularly. It seemed that the only time it was available was for the final evaluation. Perhaps 1 day a week they could be available.

		Mean Response
1. I found the Simulated Patient Encounter (SPE):		
0 1 2 3 4 5 Terrible	Enjoyable	4.32
0 1 2 3 4 5 Difficult to use	Easy to use	3.16
0 1 2 3 4 5 A waste of time	Useful	4.02
0 1 2 3 4 5 Useless for self evaluation	Helpful for self evaluation	3.70
2. I believe my performance on the SPE:		
0 1 2 3 4 5 Did not reflect my medical knowledge	Accurately reflected my medical knowledge	3.10
0 1 2 3 4 5 Did not reflect my performance on the floor	Accurately reflected my performance on the floor	2.55

3. I would be interested in using the SPE in the future for:	Responses
a) Self evaluation	46 yes, 3 no
b) Gaining experience	49 yes, 1 no
c) Testing	25 yes, 22 no

Figure VI-3. Third Year Student Survey Effectiveness of the Simulated Patient Encounter

Negative

Did it reflect performance on the floor? Some situations yes and in some no.

A waste of time.

I gained much more from the equivalent time spent in our clinical evaluation -- being thrown a totally unknown patient to interview and examine and present to a strange staff physician cannot be beaten as a stimulus to organize one's medical information in a useful way, i.e., get it together.

During the on-site visit an interview was conducted with three students. It revealed some of the problems of substituting a synthetic patient and hospital environment. The following is an excerpt from the interview:

[Student A]: *When you have a patient on the wards, even when you know the diagnosis, you spend a certain amount of time going back and saying to yourself, "What could I have done differently to have gotten to this diagnosis more quickly?" So I'm looking for signs and symptoms and tests that weren't already in my memory as things to associate with this disease. Lupus is a rare disease, I never saw it with the patients I had. From my second year I knew very few things about lupus. I knew what kind of a disease it was, some of the pathophysiology, but almost none of the signs and symptoms. So by going to the computer I at least stimulated my interest in it and I went back and saw the signs and symptoms that were there fit according to the textbook.*

[Student B]: *I have just started on the computer in the last four weeks. I had a case on hypertension. The thing that I didn't like was that when you ordered tests you couldn't get the results back.*

[Student A]; *It simulated a very inefficient hospital.*

[Student B]: *Some tests you could get on an emergency basis or advance the results. I was frustrated. When an EKG takes three days ...*

[Student A]: *But what he's saying is that if I order an EKG on Thursday I don't want to advance the time to Monday to find out. I want the results to be there on Friday. Almost every one of the tests you have to pay more to get them that fast.*

[Student B]: *The diseases that I know the best are the ones that my patients have had. You get the diagnosis on a patient and go and read about it and then you come and look at the findings again and follow them. Not as well as a live patient, but it's better than reading a textbook. I can visualize a face and see the patient and the symptoms and remember what he complained about and it's a real person that I've known!*

[Student A]: *I'd agree with that but I would insert more things in between the patient and textbook. I think that's really where your peers and teachers are a source of information. Even if it isn't related to a specific patient, you can do better than just reading the textbook which is close to worthless. Lecture would probably come before the textbook.*

[Student C]: *You don't order treatment on these patients on the computer. The only thing, absolutely the only thing you can do is order lab tests.*

[Student A]: *Yeah, but you can order tests that would be contra-indicated and kill your patient.*

[Student C]: *In one case we were going to order a cardiosymphysis of a patient and low and behold a junior staff put the patient on warfarin and had not told anybody. On the computer program this little thing comes through and says that a senior staff man stops you because the patient is on warfarin. They were doing things to this patient that you don't even know about. This was unfortunate because that was the proper diagnostic test. As it turned out the patient did have a parietal pericardia.*

[Student A]: *In a real situation if you're ordering the tests then you're probably also ordering the treatment so you know what the treatment is.*

Testing System

The measurement of clinical competence is difficult, since it involves complex tests of problem formulation, investigation, and solution.

The data available is inconclusive, but at this point the simulation mode has not proven to be a reliable testing instrument. A study of third year medical students' performance on the computer clinical encounters and other measures (ward scores, medical exam, self-assessment) of student clinical skills assessment showed no significant correlation.

It is possible that the simulations are measuring skills not measured by other tests. For example, simulations measure patient management skills, and ward scores measure interview skills, physical examination skills, and the ability to present a concise abstract of the case to the instructor.

Students don't want to rely on the simulations as a testing vehicle. Student A from the earlier interview said:

[Student A]: *It's a measure of knowledge. It doesn't very well measure whether you can reason. Do you pick up facts that are available in the patient? It's a common thing for students to have made the correct finding and not to realize it. It's almost completely a test of A plus B equals what? I hardly think I would like to take a test made up of computer simulations. I think it's a little bit like Russian Roulette. I don't think it's a good measure, either, of your decision-making ability. It's probably a little bit better than the National Board Exam. If you were going to have something like that you would want to have very common cases and not have to work through the whole case. You've got certain findings that you can spend so many questions and so many tests on and then you have to make some sort of rule-out/rule-in decision. Maybe you shouldn't have to make the correct diagnosis, but just show that you have gathered all of the pertinent information.*

My personal opinion is that your peer group and the way people see you at work is by far the most important thing. Basic performance level and being graded on something is different. The question is whether the people who review us are adequate. Whether they find the outstanding ones or not I'm not too concerned, but I think they don't have too much trouble finding the poor students. I think the poor students definitely have gotten C's from what I've heard. That passes you but you know that you're in trouble.

CORNELL UNIVERSITY MEDICAL COLLEGE

The Cornell ATS is a unique system which permits the computer to simulate normal human discourse. In an actual conversation, the student has the ability to interrupt and ask a question of his own, rather than only answering the computer's questions as with most CAI tutorials. (A sample interaction is shown in Figure VI-4.) The computer may respond by:

1. Giving a direct answer (e.g., when the student is asking about the definition of a term).
2. Asking the student a series of simpler questions to show him how to reason through the answers to the question he just asked. (ATS does not produce the question, but selects the most logical route.)
3. Telling the student it doesn't know the answer, but it will be brought to the author's attention.

ATS on the authoring side is designed for people with no knowledge of computer programming. A tutorial, on the muscles of the eye, is shown in Figure VI-5. It illustrates the second point above.

A child has a congenital weakness of his right inferior rectus. How would you test this muscle?

▱:
What is congenital?(*1)

I don't understand what you want to know about congenital.

▱:
What it means(*2)

Congenital means something that exists from birth.
Now we'll return to where you were before asking your question.(*3)

A child has a congenital weakness of his right inferior rectus. How would you test this muscle?

▱:
I would have the patient aduct his eye and look inferiorly.

By aduct, do you mean adduct or abduct? (*4)

▱:
Abduct

You would ask him first to abduct his eye. To make the long axis of the eyeball and long axis of the muscle parallel, and then ask him to look inferiorly to test the muscle.

The extrinsic ocular muscles tend to work conjugately or in pairs. What muscle would you be testing in the left eye while you were testing the right inferior oblique?

▱:
I would be testing the left rectus.

I was expecting rectus with some other words.(*5)
Please rephrase your whole answer.

▱:
I would be testing the left superior rectus.

---

*1 ATS understand that student is asking, not answering a question, and keeps him in conversation until a common ground for discussion can be reached.

*2 ATS understands student's question even though he has abbreviated his discourse by (a) not using a question mark, and (b) using a pronoun. The program remembers the referent of the pronoun.

*3 ATS keeps track of where the student was, so that student can direct his own session by asking questions, but when his questioning ends, he returns to control of the program for determination of the most appropriate sequence of questions.

*4 Spelling or typographical errors are automatically handled by the program, without the author's having to plan for them.

*5 When an answer is partially correct, the program intervenes as it does in all cases of default by the author. In this instance, the program prompts the student to give a more complete answer.

THESE FEATURES OF ARTIFICIAL INTELLIGENCE ARE INTRINSIC TO THE PROGRAM. THE AUTHOR NEEDS ONLY BE CONCERNED WITH CONTENT.

Figure VI-4. Sample Student Interaction Illustrating Artificial Intelligence

2 What is the action of the superior rectus?

□:
Internal Rotation
Any muscle inserting on the superior surface produces internal rotation. (Fig. 4A)

3 Assume that he starts with his eye adducted, What is the action of the superior rectus (Fig. 5A)?

□:
Internal Rotation
It causes internal rotation, since the long axis of the eyeball and the long axis of the muscle are at right angles.

4 Assume that he starts with his eye abducted. What is the action of the superior rectus (Fig. 6A)?

□:
The long axis of the muscle and the axis of the eyball are parallel, so movement is either superior or inferior.
It causes the eye to look superiorly, since the long axis of the muscle and the long axis of the eyeball are parallel.

8 On which surface of the eyeball does the superior rectus insert?

□:
The superior surface
Any muscle inserting on the superior surface produces internal rotation (Fig. 4A).

13 Where does the superior rectus insert relative to the equator of the eyeball (Fig. 8)?

□:
Anterior
Any muscle inserting anterior to the equator and approaching from the medial side causes adduction (Fig. 2A). If it also inserts on the superior surface it makes the eye look superiorly (Fig. 3A).

2 What is the action of the superior rectus?

□:
It depends on the starting position of the eye.
It does depend on the starting position of the eye.

4 Assume that he starts with his eye abducted. What is the action of the superior rectus (Fig. 6A)?

□:
Eye will look superiorly
It causes the eye to look superiorly, since the long axis of the muscle and the long axis of the eyeball are parallel.

7 How would you test the superior rectus, i.e., what would you ask the patient to do?

□:
I would ask him to abduct his eye, and look superiorly.
You would ask him first to abduct his eye, to make the long axis of the eyeball and long axis of the muscle parallel, and then ask him to look superiorly to test the muscle.

Figure VI-5. Sample Tutorial

A student opinion survey indicates that a majority (57%) of students prefer the open-ended question format in ATS over multiple choice questions. The students rated the quality of the course material in the CAI tutorials as average to good, with 2 ratings of excellent out of 50 responses.

The student evaluation of the computer tutorials revealed:

I find the tutorials:	Percentage selecting this category:
Fun and worthwhile	26
Fun but not especially worthwhile	17
Worthwhile but trying	13
Frustrating	13
Time-consuming	13
Tedious	13
Insensitive and impersonal	5

The answer to the question on the contributions of the materials to learning was:

Significant	29%
Somewhat	85%
Not at all	13%

Overall, the survey shows that students did not consider the tutorials as a very important factor in their study of anatomy.

UNIVERSITY OF KANSAS MEDICAL CENTER

The University of Kansas' instructional program, like that of the University of Illinois School of Basic Medical Sciences, has both a CAI and a CMI component.

At the University of Kansas the CMI component has a dual purpose: it is used for testing and it serves as a learning experience. Students are allowed to take examinations as many times as they wish to raise their competency level. At the University of Illinois, the CMI exams are for self-evaluation only. Students are not graded until they take a comprehensive examination at the end of the school year.

The CAI component at Kansas consists of tutorials, review questions, and case histories (primarily in the area of toxicology). This component at the University of Illinois sometimes combines modes; e.g., simulation to tutorial, and back to simulation, as described earlier in this chapter.

The case histories at the University of Kansas are problem-solving encounters. In working through a case history, the student is provided with basic data such as patient age, appearance, symptoms, etc. He can then request additional data. If his lack of knowledge prevents him from requesting the proper data, the program will eventually volunteer information such as blood pressure, respiration rate, lab test results, so that he can proceed with the case. If he requests data which is inappropriate to the symptoms (e.g., respiration rate for a patient with abdominal pain) the system reprimands him and asks him to make another request.

The objective of the cases differs. In some an agent which has been ingested is known and the student's task is to recommend the proper treatment. In others the objective is to learn what has been ingested. A third type combines these; the student is asked to identify the toxic agent and to prescribe treatment.

These cases are not suitable testing mechanisms because they are limited in scope; i.e., each covers only two or three points of information. During the course of the history, perhaps 15 facts are introduced, and from these facts five or six principles will emerge.

The case histories used at the University of Kansas differ from simulations such as those at the University of Wisconsin in that the computer does not perform calculations. The Kansas case histories are similar to those used at Massachusetts General Hospital.

When one considers the effectiveness of modes it is useful to contrast CAI with other modalities. A survey was made at the University of Kansas Department of Pharmacology in which modes that provide alternative ways to learn the material were presented for student ranking. The modes were divided into two groups: the first had to do with a comparison of modes for acquiring basic medical knowledge; the second group was concerned with clinical problem-solving. The results of student preferences are shown in Tables VI-1 and VI-2.

Referring to Table VI-1, we will first consider the preferred modes (1st and 2nd preferences) for acquiring the basic knowledge, using primarily didactic instructional methods. The following ranking emerges:

MODE	COUNT
CAI	46
Labs	23
Lectures	18
Discussion groups (remedial sessions)	9
Audio visual	9

It is evident that CAI is strongly preferred over A/V. Our study did not include an investigation of available A/V materials, and perhaps its low ranking is influenced by a lack of availability of them in Pharmacology.

Table VI-1. Student Learning Preferences in Pharmacology

Learning Mode \ Ranking	1	2	3	4	5
Lecture	7	11	14	15	3
Lab	4	19	22	2	1
Discussion Group	2	7	5	14	19
CAI	38	8	3	1	4
Audio Visual	0	9	4	11	17
Demonstrations	0	0	2	3	0

Table VI-2. Student Preferences for Acquiring Problem-Solving Skills in Pharmacology

Problem-Solving Learning Mode \ Ranking	1	2	3
Clinical Conference	7	17	21
CAI Case History	17	21	11
Labs*	27	11	12

*Primarily in toxicology

In considering CAI versus traditional lectures, it can be seen that there is considerable disagreement on the value of lectures, while there was a good concensus on the value of CAI. It should be noted that only 7% of 159 students used CAI for less than an hour.

For the group discussions, the results are not surprising since they are generally attended by those who need special help, although it is still surprising that they received the greatest number of votes as being at the bottom of the ladder.

For testing of drug therapeutics and drug-related clinical problems (Table VI-2), the laboratories (primarily in toxicology) were preferred over the computer problem-solving cases. The CAI case problems, however, were greatly preferred over the clinical conference.

The CAI method, in both of the above types of instructional situations, was considered to be an effective method of presenting instructional materials. The average usage level of 22.48 hours indicates that it was a primary learning mode for students at the University of Kansas.

A different view was a survey question concerning which method of independent study students found to be most effective. (See Table VI-3.) A summary of first and second preferences is:

MODE	COUNT
Syllabus	49
CAI	26
Textbook	19
Tests (Unit exams as a learning method)	11
Faculty consultation	3
Peer group	0

Table VI-3. Student Preferences for Methods of Independent Study

ISI Learning Mode \ Ranking	1	2	3	4	5	6
Syllabus	40	9	3	4	5	1
Res. textbook	4	15	6	18	8	2
CAI-Review Questions	4	22	17	7	1	1
Unit Exams	3	8	21	16	1	2
Faculty Consultations	2	1	6	2	20	15
Peer Group	0	0	1	6	11	19

A detailed 300-page syllabus is the major study vehicle. Some students commented that they did not attend lectures because they were repetitive of what was contained in the syllabus. Also, the syllabus was the basis for many of the test questions.

The survey revealed that CAI is a more popular way to learn than are textbooks. This was confirmed when students indicated on the survey form that feedback was an important advantage that CAI has over the textbook mode. It appears that students feel neutral about using examinations as a vehicle for learning. However, on the average, each of five examinations were taken 2.3 times. Several poor students took the unit exams as many as four times to obtain a passing grade. This learning method may have been ranked as mediocre because students do not

think of the exams as a learning mechanism, but only as an opportunity to raise their grade. However, as a tool for pointing out deficiencies for further study, they are important to the curriculum.

The low ranking given to consulting with faculty may be explained by the fact that this is not emphasized in the instructional program and there are no formally scheduled counseling sessions with faculty. In the instructional programs at other medical schools each student has a conference with his instructor which lasts for an hour or more to review his examination.

Chapter VII

STUDENT PERFORMANCE

Study Question:

Does CAI improve student performance?

None of the schools included in this study have conducted controlled experiments; however, some data are available on which interpretations can be made concerning the effect of CAI on achievement.

There were cases where dramatic gains in performance were made, but because of many uncontrolled variables, we cannot make unequivocal statements on CAI effectiveness. For example, students were not limited to only one method of instruction, they did not take standardized exams at the same juncture of their course unit, and they had varying academic abilities.

THE UNIVERSITY OF WISCONSIN SCHOOL OF MEDICINE

The clinical simulations at this institution have a dual role: for testing and as a teaching tool. However, the main focus is on research and development; that is, to validate the clinical encounter model.

Use is voluntary, and there is no attempt to incorporate the cases into an overall teaching program. Therefore, it is inappropriate to compare the performance of CAI users and non-users on National Board scores or other performance measures.

Students who took the simulations, however, viewed them as a learning experience and as a check on their clinical competence. Performance on the simulations was not considered in calculating grades.

In order to study the question of the validity of the clinical model a study was conducted that:

1. Compared student scores on the clinical encounters with other clinical competence measures.
2. Compared performance of students with house staff on clinical encounters.

Three factors utilized in scoring a patient management problem are:

1. Cost: Total cost of all tests ordered and therefore "charged to the patient," whether or not the results were ever seen, plus cost per day for the time the patient remained in the hospital before correctly diagnosed.

2. Time: Total real time spent on case workup at the terminal.

3. Competence Index (or CI): The steps for calculating the CI are:

Step 1: Assign each item to one of the following categories

+++ Essential to do	- Useless
++ Important to do	-- Harmful
+ Helpful	--- Essential to avoid
0 Optional	

Step 2: Assign a system of weights to each category, for example

+++ = +10	- = -1
++ = +5	-- = -5
+ = +1	--- = -10

Step 3: Calculate the maximum score that could be obtained by selecting all the + items on the optimal route and avoiding all the - items; this equals the maximum possible score.

Step 4: For each examinee calculate the following scores for the total and each subtest:

$$\text{Efficiency (EI)} = \frac{\text{number of positive items selected}}{\text{total number of items selected}}$$

$$\text{Proficiency (PI)} = \frac{\text{weighted (algebraic) sum of items selected}}{\text{maximum possible score}}$$

$$\text{Errors of Omission (OM)} = \frac{\text{weighted sum of the positive items NOT selected}}{\text{maximum possible score}}$$

$$\text{Errors of Commission (COM)} = \frac{\text{weighted sum of the negative items selected}}{\text{maximum possible score}}$$

$$\text{Competence Index (CI)} = \text{a combined function of efficiency and proficiency}$$

The simulation was utilized to evaluate all third year students during their medical rotation for the years 1972-1973 and 1973-1974. There were no statistically significant correlations between the students' performance on the simulation using the CI and either the instructor's evaluation of their performance (ward score) or multiple-choice medicine examinations (self-evaluation and National Board).

On one clinical case (out of 7 cases used in the study), there was a significant correlation with the time and cost scoring factors:

Med 3's, 1973:	T-Transformations		
	Significance	Correlation	Count
Cost9/ward score	.002	-.456	42
Cost9/M-question	.009	-.417	38
Time9/ward score	.002	-.514	33

This negative correlation is the logical relationship since a low cost workup or shorter time may indicate a higher level of clinical competence as reflected in the ward score and M-question (self-evaluation examination part involving questions on medical knowledge).

While almost no correlations were found between the simulator scores and the other measures, it was found that the written exam scores correlated with each other and with the composite score and the clinical grade. Does this mean that the simulator model is invalid? Not so! The simulation may measure different dimensions of clinical competence. The cost factor may be considered a measure of patient management skills, the CI is a measure of both diagnostic skills, and time.

The multiple choice exams may be primarily an evaluation of the students' medical knowledge rather than problem-solving skills. The hard score is an

evaluation of student's interviewing skills and his ability to present the medical findings only, since the student is not given responsibility for patient management.

On the other hand we would expect the house staff to have better scores than students on the simulation cases. In the study, each group's values of time, cost, and CI were compared on six cases. T-test results showed only one comparison could be considered significant:

	Students	Staff	Signif. Level
Case 10, cost	131	29	.000

Unfortunately for our presumption, however, this comparison was in favor of the third-year students:

	Group Mean	F-Ratio	Group Std. Dev.
131 students	$298	12.678	$154
29 staff	478		480

The result, however, may be due to case difficulty. Case 10 is an easy case. The house staff may have anticipated a more difficult diagnosis problem and therefore made more laboratory tests than needed.

In an earlier study the opposite results were found (Friedman, 1973). House staff out-performed students on a number of variables as shown below:

PHYSICIAN PERFORMANCE ACCORDING TO TRAINING

Group	Number	Patients Expiring[1]	Incorrect Diagnosis Per Case[2]	Average Cost[2]	Average Hospital Stay/days[3]	Elapsed Time[4]
Medical student	6	2	1.2	$1,020	6.5	50
House staff	7	1	.5	348	2.0	35
Senior staff	9	2	1.3	736	4.3	25

[1] Patients expiring prior to correct diagnosis.
[2] Penalty for incorrect diagnoses was $200 and 2 days in hospital.
[3] Patients who expired prior to correct diagnoses not included.
[4] Average minutes per session.

Since the average workup cost ($1,020) in the earlier study was double the current study it may be inferred that the cases used in the earlier study were of a greater difficulty.

UNIVERSITY OF KANSAS MEDICAL CENTER

The research question posed is as follows:

> *Does the amount of time a student spends using the computer have an effect on his grade in the course?*

To provide answers to this question several different types of data were gathered on students (N=85) in a Pharmacology course at the University of Kansas Medical Center; the measures taken were:

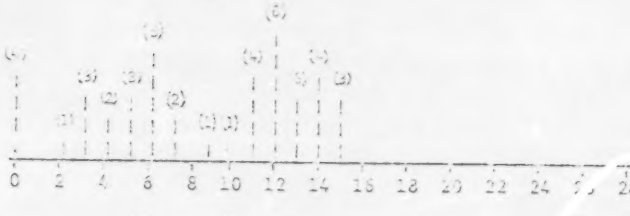
- Number of hours spent studying CAI materials
- Grade in course
- MCAT Scores
  - Variable
  - Quantitative
  - General Information
  - Science
- Cumulative Grade Point Average
- Total Attempts at Course Tests

Time Spent on CAI Materials

Table VII-1 shows the distribution of hours "on-line" for the high and low user groups used in the study. Table VII-1 also presents the means and standard deviations for the number of hours spent by each group; a statistical test of the difference between the means was significant ($t = 17.798$, $p < .00005$, $df = 83$). Thus the students selected for the sample can be reliably characterized as consisting of two types of computer users; for convenience of exposition we will refer to those who fall within the group with mean hours usage equal to 39.4 as "high users" while those who fall within the group with mean usage equal to 8.49 hours will be referred to as "low users." Subsequent analyses will be based on the distinction drawn between the groups.

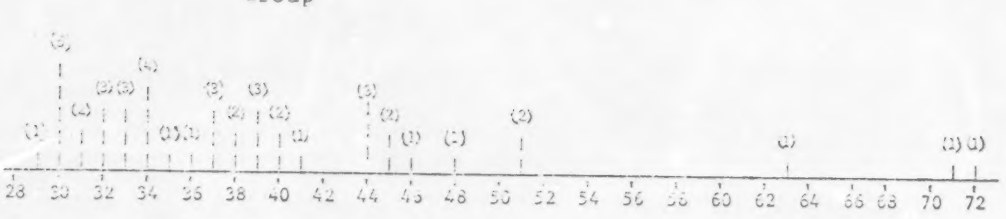
Table VII-1. Frequency Distribution of Time Spent (in Hours) using CAI Material of Study Groups.

"Low" User Group



N = 42
Mean = 8.49
s.d. = 4.86
Range = 0 - 14.983

"High" User Group



N = 43
Mean = 39.39
s.d. = 10.30
Range = 28.65 - 73.95

92

Course Grades and Computer Usage

Final grades in the pharmacology course, based on four unit tests and a final exam (all equally weighted) were: A (80-100 points), B (75-80), C (70-75), D (65-70), and F (less than 65); only the letter grades were available for purposes of this study. To provide a broader range of grade categories, the medical school further divided the "A" students into "high A" (A+) and "low A" (A-); thus six categories of course grades were available. Table VII-2 shows the distribution of course grades over high and low CAI users. The Kalmogorov-Smirnov two-sample test was performed on the data in the table to determine if the distribution of grades was different between the two groups; the result showed that the groups were indeed different ($D = .302$, $p < .05$). Examination of Table VII-2 shows that the principal difference between high and low users is in the number of C and B grades awarded; while there were 24 C's and only 2 B's among the low group, the high users had 15 C's and 15 B's. It would appear that the effect of computer practice manifests itself among the students whose performance in the course might be said to be "marginal" -- hovering, if you will, between relatively good and relatively poor subject matter acquisition.

A potentially confounding influence on the above findings stems from the fact that students in the pharmacology course were permitted to take each of the five tests as many times as they wished with the best score from each test entered into the computation of the course grade. Since the repeated taking of tests (and the presumed preparative study for each attempt) constitutes a form of practice, any difference between the two groups in the frequency of test-taking could distort the differences found in the course grades. To examine the influence of test-taking the frequency of attempts for high and low users was determined and tested for statistical significance. The data are presented in Table VII-3. The data indicate that the high users tended somewhat

Table VII-2. Distribution of End-of-Course Pharmacology Grades for High Users and Low Users of CAI.

	Grade						
	A+	A-	B	C	D	F	
High	5	3	15	15	4	1	43
Low	5	3	2	24	8	1	43
	10	6	17	39	12	2	86

Table VII-3. Distribution of Total Number of Attempts at Pharmacology Tests (summed over four unit tests and one final test) for High and Low Users of CAI.

	Number of Attempts at Tests							
	0-4	5-7	8-10	11-13	14-16	17-19	20-22	
High	0	1	7	22	6	5	0	41
Low	1	4	13	14	7	0	1	40
	1	5	20	36	13	5	1	81

to take more tests than the low; however, the Kalmogorov-Smirnov test showed that the difference between the two distributions is not significant ($D = .256$, $p > .10$). Thus we may conclude that the effect of test-taking frequency did not appreciably influence the differences found in course grades between high and low computer users.

Another potential source of bias in the grade differences found between high and low computer users lies in the aptitudes and level of academic accomplishment characterizing the students participating in the study. If it were found that the high users had significantly greater MCAT scores and cumulative grade point averages than the low users, then the differences found in pharmacology grades could reasonably be attributed to these factors rather than the computer experience. However, such is not the case. Table VII-4 shows that for each MCAT score as well as cumulative GPA, the mean of the low users was greater than that of the high users; t-tests indicate that three of the measures, MCAT Variable, General Information, and Science, differ for the groups to a degree that attains or exceeds conventional levels of statistical significance. Tables VII-5 through VII-8 show the distribution of each of these measures for high and low computer users. In each case it may be seen that the number of students falling in the upper range of values is greater for low users than for high.

It would appear then that, to the extent ascertainable in the present study, the benefits obtained from CAI applications to the pharmacology course are real. It is particularly significant that despite the fact that high users were characterized by lesser aptitude and past academic achievement, they had higher grades for the course (cf of Table VII-2).

Table VII-4. Means, Standard Deviations and Tests of Significance for High and Low Users on MCAT Scores and Cumulative Grade Point Average

	High Users		Low Users			
MCAT SCORES	Mean	s.d.	Mean	s.d.	t	p
Verbal	58.95	25.48	69.93	24.11	-1.85	.06
Quantitative	61.14	23.27	67.71	22.62	-1.32	.19
General Information	56.84	28.49	68.38	21.61	-2.10	.03
Science	62.14	21.24	76.10	14.89	-3.50	.0008
Cumulative GPA	3.49	0.49	3.61	0.36	-1.20	.23

Table VII-5. Distribution of MCAT "Variable" Scores for High and Low Users of CAI.

	MCAT "Variable" Scores										
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	
High	1	3	3	3	3	7	9	5	2	7	43
Low	1	0	1	1	4	8	3	9	8	8	43
	2	3	4	4	7	15	12	14	10	15	86

Table VII-6. Distribution of MCAT "Quantitative" Scores for High and Low Users of CAI.

	MCAT "Quantitative" Scores										
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	
High	1	2	2	2	6	7	5	8	4	6	43
Low	0	0	2	4	7	0	4	5	13	8	43
	1	2	4	6	13	7	9	13	17	14	86

Table VII-7. Distribution of MCAT "General Information" Scores for High and Low Users of CAI.

	MCAT "General Information" Scores										
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	
High	2	4	5	2	1	4	5	10	6	4	43
Low	1	1	0	2	6	2	7	10	7	7	43
	3	5	5	4	7	6	12	20	13	11	

Table VII-8. Distribution of MCAT "Science" Scores for High and Low Users of CAI.

	MCAT "Science" Scores										
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	
High	1	1	1	2	6	6	7	8	10	1	43
Low	0	0	0	0	2	4	7	7	15	8	43
	1	1	1	2	8	10	14	15	25	9	86

Information of this sort may be of use in counseling other students as to the most effective means of studying the components of their discipline; students identified as potentially low users could be given special encouragement to employ the computer-based materials.

UNIVERSITY OF HAWAII SCHOOL OF MEDICINE

The School of Medicine at the University of Hawaii has utilized the University of Kansas' CATS for two years, and during that period the performance of students has shown dramatic improvement.

This university uses only the CMI portion of the CATS system, but the course unit tests are used as a learning tool as much as a measurement device. The ranking of the students in the pharmacology portion of the National Boards is as follows:

Year	Ranking Pharmacology Portion of Examination
1970	23
1971	60
1972	15
1973	38
1974*	4
1975*	9

* CMI system used in teaching.

The scores did improve significantly after the CMI system was instituted. The 1975 mean score was raised from 425 to 525, approximately. Scores in biochemistry and pathology (which did not use CMI) also improved during the last two years, although not as dramatically as in pharmacology. The latter

suggests that the School of Medicine has better students than before. Thus, it is impossible to state objectively what the impact of CMI might have been.

Dr. Bert K. Lum, Chairman of the Department of Pharmacology, stated that his subjective impression is that CMI made a difference in performance on the Boards beyond that explained by the better quality of students.

REFERENCES

ANDERSON, R.C. "The Comparative Field Experiment: An Illustration from High School Biology." Proceedings of the Invitational Conference on Testing Problems. Princeton: Educational Testing Service, 1969.

AVNER, Elaine. PLATO User's Memo: Summary of TUTOR Commands and System Variables. Computer-based Education Research Laboratory, University of Illinois-Urbana, June 1975.

BIGELOW, Gordon S. and Egbert, Robert L. "Personality Factors and Independent Study." Journal of Educational Research, September 1968, 62, 37-39.

BOGNER, Phyllis H., Sajid, Abdul W., and Clemmons, J.D. "Relationship Between Habits and Traits of Medical Students and Performance on Examinations." The Physiology Teacher, July 1975, 4, 4-6.

CHICKERING, A.W. "Dimensions of Independence." Journal of Experimental Education, Spring 1964, 32, 313-316.

FOLK, Robert L., et al. Individualizing the Study of Medicine. Westinghouse Learning Corporation, 1976.

FRIEDMAN, Richard B., M.D. "A Computer Program for Simulating the Patient-Physician Encounter. Journal of Medical Education, Vol. 48, January 1973.

GRIESEN, James V. Independent Study Versus Group Instruction in Medical Education: A Study of Non-cognitive Factors Relating to the Curricular Preferences and Academic Achievement. PhD Dissertation, The Ohio State University, 1971.

HARLESS, William G., et al. GENESYS--A Generating System for the CASE Natural Language Model. Center for Educational Development, University of Illinois College of Medicine, Chicago. Rev. April 1973.

HARLESS, William G., et al. CASE--A Natural Language Computer Model. Center for Educational Development, University of Illinois College of Medicine, Chicago. Rev. April 1973.

MATZNER, Kenneth E., Essex, Diane L., and Gamble, Thomas. Diagnostic Inventory for Student Self-selection into Independent Study Versus Traditional Program of Medical Sciences. School of Basic Medical Sciences at Urbana-Champaign, University of Illinois College of Medicine, 1976.

OLMSTEAD, Ann G. "Basis of Attraction to Medicine and Learning Style Preferences of Medical Students." Journal of Medical Education, June 1973, 48, 572-576.

REZLER, Agnes. "Materials for the Evaluation Section Meeting on October 8--The Learning Preference Inventory." (Xerox) University of Illinois, College of Medicine, Chicago, IL, 1975.

RUBIN, Martin., Hunter, Beverly and Knetsch, Marilyn. Evaluation of the Experimental CAI Network (1973-1975) of The Lister Hill National Center for Biomedical Communications, National Library of Medicine. Alexandria, VA: Human Resources Research Organization, 1975.

Appendix A

LIST OF CONTACT PERSONNEL

WISCONSIN, UNIVERSITY OF, SCHOOL OF MEDICINE

Richard Friedman, M.D.
Assistant Professor of Medicine
Department of Medicine
University of Wisconsin
427 Larch Street (Room 225)
Madision, WI 53706

Ellouise Beatty
Project Specialist
Department of Medicine
University of Wisconsin
427 Larch Street
Madision, WI 53706

Harry Stone, PhD
Assistant to the Vice Chancellor
Center for Health Sciences
University of Wisconsin
1300 University Avenue
Madison, WI 53706

Marklynn Jenkins
Voice Response System Specialist
Department of Medicine
University of Wisconsin
427 Larch Street
Madison, WI 53706

Sun Ming Cheung, Engineer
System Development Interface
Department of Medicine
University of Wisconsin
427 Larch Street
Madison, WI 53706

Lindi Siegel
CBX Project, Scriptwriting
Department of Medicine
University of Wisconsin
427 Larch Street
Madison, WI 53706

David Graham, MD, Chairman
Department of Medicine
University of Wisconsin
427 Larch Street
Madison, WI 53706

Larry VanCura
Programmed Medicine
Department of Medicine
University of Wisconsin
427 Larch Street
Madison, VI 53706

CALIFORNIA, UNIVERSITY OF, SCHOOL OF MEDICINE

Martin Kamp, MD
Chief, Academic Computer Services
Office of Information Systems
San Francisco Medical Center
San Francisco, CA 94143

James Starkweather, PhD
Director, Computer Center
Office of Information Systems
San Francisco Medical Center
San Francisco, CA 94143

Steven Kornberg, Resident Associate
Office of Information Systems
San Francisco Medical Center
San Francisco, CA 94143

William Bargagliotti, Director
Self-Instruction Media Area
Room 345 HSE
San Francisco Medical Center
San Francisco, CA 94143

CALIFORNIA, UNIVERSITY OF, SCHOOL OF MEDICINE

Edward Deland, PhD
Department of Thoracic Surgery
UCLA School of Medicine
Los Angeles, CA 90024

Jeffrey Sue
Member, CAI Curriculum Committee
UCLA School of Medicine
Los Angeles, CA 90024

Joshua Levy, M.D.
Assistant Professor
Department of Medicine
UCLA School of Medicine
Los Angeles, CA 90024

Bernice Wenzel, PhD
Assistant Dean for Educational Research
UCLA School of Medicine
Los Angeles, CA 90024

Gloria Werner
Assistant Biomedical Librarian
Medical Center
UCLA School of Medicine
Los Angeles, CA 90024

Donald O. Walter, M.D.
Professof of Neurology and Psychiatry
Brain Research Institute, Room 3-384
Center for Health Sciences
UCLA School of Medicine
Los Angeles, CA 90024

Steven Suffin
Resident, Physiology
UCLA School of Medicine
Los Angeles, CA 90024

CORNELL UNIVERSITY MEDICAL COLLEGE

W.D. Hagamen, M.D., Director
Laboratory of Computer Science
Cornell University Medical College
New York, NY 10021

Jane Hirsch
ATS Coordinator
Laboratory of Computer Science
Cornell University Medical College
New York, NY 10021

John Daniels, Director
Computer Center
Laboratory of Computer Science
Cornell University Medical College
New York, NY 10021

John C. Weber, DDS
Associate Professor of Anatomy
Department of Anatomy
Cornell University Medical College
New York, NY 10021

Dana Brooks
Professor of Anatomy
Cornell University Medical College
New York, NY 10021

Thomas Baker, Associate Professor of Pharmacology
Department of Pharmacology
Cornell University Medical College
New York, NY 10021

F.G. Girgis, MD
Associate Professor of Anatomy
Department of Anatomy
Cornell University Medical College
New York, NY 10021

KANSAS, UNIVERSITY OF, MEDICAL CENTER

Edward J. Walaszek, PhD
Professor and Chairman
Department of Pharmacology
University of Kansas Medical Center
Rainbow Boulevard at 39th
Kansas City, KS 66103

John Doull, MD
Professor of Pharmacology and Toxicology
Department of Pharmacology
University of Kansas Medical Center
Rainbow Boulevard at 39th
Kansas City, KS 66103

Edward Nelson, MD
Professor of Pharmacology
Department of Pharmacology
University of Kansas Medical Center
Rainbow Boulevard at 39th
Kansas City, KS 66103

A.J. Yarmat, PhD, Director
Division of Learning Resources
University of Kansas Medical Center
Rainbow Boulevard at 39th
Kansas City, KS 66103

Russell Mills, MD
Director and Administrator
University of Kansas Medical Center
Rainbow Boulevard at 39th
Kansas City, KS 66103

Donald Gresham, MD
Director of Computer Programming
Department of Computer Services
University of Kansas Medical Center
Kansas City, KS 66103

PACIFIC, UNIVERSITY OF THE, PACIFIC MEDICAL CENTER

Barry Brinkley, MS, AART
Director, BSAP-RT Project
Presbyterian Hospital
Pacific Medical Center
San Francisco, CA 94120

Nancy Farr
MERIT Project Coordinator
Pacific Medical Center
P.O. Box 7999
San Francisco, CA 94120

John Gamble, MD
MERIT Project
Co-Principal Investigator
Pacific Medical Center
P.O. Box 7999
San Francisco, CA 94120

William G. Harless, PhD
MERIT Project
Principal Investigator
Pacific Medical Center
P.O. Box 7999
San Francisco, CA 94120

Marcia Zier
Research Associate
MERIT Project
Pacific Medical Center
P.O. Box 7999
San Francisco, CA 94120

ILLINOIS, UNIVERSITY OF, SCHOOL OF BASIC MEDICAL SCIENCES

Allan H. Levy, MD., Director
Medical Computing Laboratory
School of Basic Medical Sciences
University of Illinois
at Urbana-Champaign
567 Medical Science Building
1025 W. California
Urbana, IL 61801

Richard Stull, PHD
Content Specialist
Computer-based Education Project
School of Basic Medical Sciences
University of Illinois
at Urbana-Champaign
1115 West Oregon St.
Urbana, IL 61801

C. Coe Agee, PhD
Content Specialist
Computer-based Education Project
School of Basic Medical Sciences
University of Illinois
at Urbana-Champaign
1115 West Oregon St.
Urbana, IL 61801

Kenneth Wagner, PhD
Content Specialist
Computer-based Education Project
School of Basic Medical Sciences
University of Illinois
at Urbana-Champaign
1115 West Oregon St.
Urbana, IL 61801

Rodger McCormick, PhD
Content Specialist
Computer-based Education Project
School of Basic Medical Sciences
University of Illinois
at Urbana-Champaign
1115 West Oregon St.
Urbana, IL 61801

William Sorlie, PhD, Assistant Dean
for Curriculum Development
Office of Curriculum Evaluation
School of Basic Medical Sciences
University of Wisconsin
at Urbana-Champaign
255 Medical Science Building
1025 W. California
Urbana, IL 61801

L.A. Jones, PhD
Office of Curriculum Evaluation
School of Basic Medical Sciences
University of Wisconsin
at Urbana-Champaign
255 Medical Science Guilding
1025 W. California
Urbana, IL 61801

William Golden
Computer-based Education Research
Laboratory
School of Basic Medical Sciences
University of Wisconsin
at Urbana-Champaign
504 Medical Science Guilding
1025 W. California
Urbana, IL 61801

William Daniel, PhD, Assistant Professor
School of Basic Medical Sciences
University of Wisconsin
at Urbana-Champaign
504 Medical Science Building
1025 W. Californiw
Urbana, IL 61801

George Hody, MD, Consultant to
Computer-based Education Projeet
School of Basic Medical Sciences
University of Illinois
at Urbana-Champaign
1115 West Oregon St.
Urbana, IL 61801

Thomas Gamble, PhD, Assistant Dean
for Student Affairs
School of Basic Medical Sciences
University of Wisconsin
at Urbana-Champaign
190 Medical Science Building
1025 W. California
Urbana, IL 61801

Appendix B

UNIVERSITY OF KANSAS MEDICAL CENTER

STUDENT QUESTIONNAIRE

Survey of Student Attributes Related to CAI

QUESTIONNAIRE

1. I found the computer-assisted instruction (CAI) in pharmacology to be:

   [ ] Very useful

   [ ] Useful

   [ ] Not very useful

   Why? _____

_____

_____

_____

2. Among the following didactic instructional methods, the rank-order of their effectiveness to me was (rank by numbers 1-5, with No. 1 being the most effective):

   [ ] Lectures

   [ ] Laboratory

   [ ] Discussion groups, including remedial sessions

   [ ] CAI self-instruction (tutorials)

   [ ] Audiovisual presentations

   Comments: _____

_____

_____

_____

3. Among the following methods of problem-solving with drug therapy, the rank-order of their effectiveness to me was (rank by numbers 1-3, with No. 1 being the most effective):

   [ ] Clinical conferences on drug therapy

   [ ] CAI case histories

   [ ] Laboratory work

4. Among the following methods of individual study, the rank-order of their effectiveness to me was (rank by numbers 1-6, with No. 1 being the most effective):

   [ ] Syllabuses

   [ ] Research using textbook

   [ ] CAI review questions

   [ ] Pharmacology course unit examinations

   [ ] One-to-one interaction with faculty consultant

   [ ] Study with peer group

5. I rate the usefulness of the following features of the pharmacology curriculum as follows (check one for each):

Feature	Very Important	Moderately Important	Not Important
(a) I could proceed at my own rate of learning.	[ ]	[ ]	[ ]
(b) The computer's frequent and rapid feedback on my progress.	[ ]	[ ]	[ ]
(c) Computer instruction available at any time.	[ ]	[ ]	[ ]
(d) Exams an instructional tool, not normal curve grading.	[ ]	[ ]	[ ]
(e) Computer diagnosis of learning weakness and possible remediation.	[ ]	[ ]	[ ]
(f) Exams on student demand.	[ ]	[ ]	[ ]
(g) Self-evaluation of level of preparation (review questions and exam).	[ ]	[ ]	[ ]

6. The pharmacology curriculum emphasized self-directed study. I found that this:

   [ ] Increased my motivation to study

   [ ] Created self-discipline problems

   [ ] Did not affect my study habits

Survey of Student Attributes Related to CAI

7. Check the following statement that applies to you.

   [ ] I attended Advanced Pharmacology discussion groups.

   [ ] I received a Superior certification.

   [ ] I wrote a teaching program for the computer.

   [ ] I had to attend Unit Extender sessions.

8. Select the block on the scale for each pair of personality attributes which generally describes your behavior in a work or study environment. If you find that you are sometimes at one extreme and at other times you are at the other, choose the one that is predominant.

Reserved				Outgoing

Expedient (to get job done)				Accepted (proper) Procedure

Experimental				Conservative

Unstructured				Structured (external controls, schedules)

Assertive (insistence on own plan)				Guidance by others

Originator (ideas, events)				Follower of ordinary course of events

Impulsive (acting momentarily without assessing possible consequences)				Pragmatic (mindful of results that would be produced)

9. The primary reason(s) that I used [ ] did not use [ ] CAI materials is/are:

_____

_____

_____

_____

_____

_____

_____

Appendix C

LIST OF INITIALIZATIONS AND ABBREVIATIONS

ATS	A Tutorial System
CAI	Computer-Assisted Instruction
CASAM	Computer-Assisted Self-Assessment in Medicine
CATS	Computer-Assisted Teaching System
CBLM	Computer-Based Learning Materials
CMI	Computer-Managed Instruction
GENESYS	Case Generating System
MERIT	Model for Evaluation and Recertification through Individualized Testing
MUMPS	Massachusetts General Hospital Utulity Multi-Programming System
OS	Operating System
PILOT	Programmed Inquiry, Learning or Teaching